RADIO and ELECTRONICS

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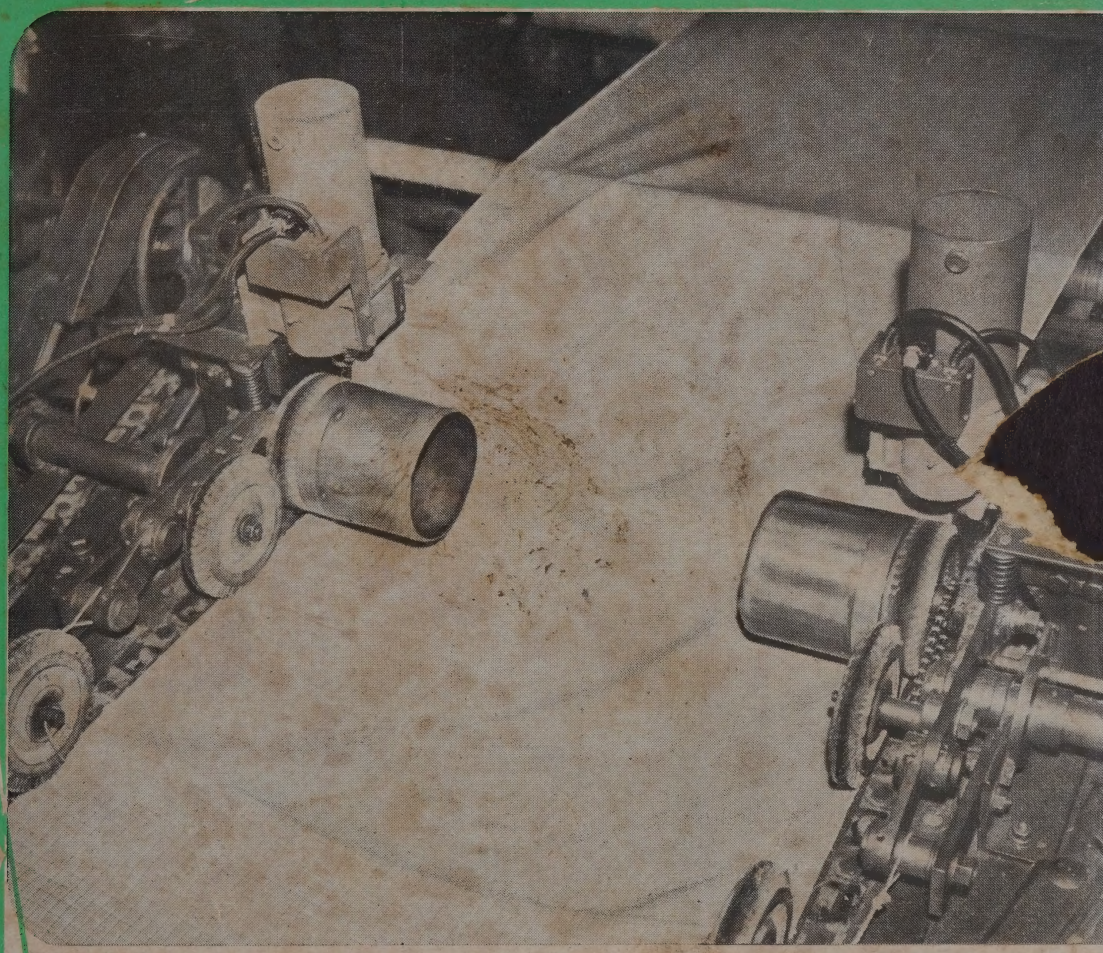

In this Issue: A New Triode Amplifier for 6A3s.

1st, 1951 VOL. 6, NO. 8 1/10

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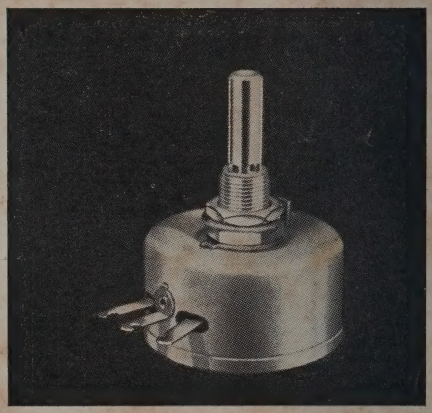

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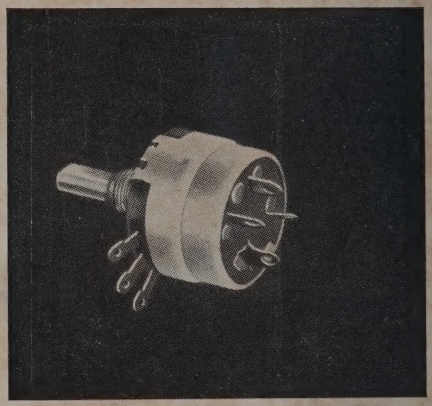

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RADIO AND ELECTRONICS

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GUY E. MILNE
ELECTRONIC TECHNICIAN

ELECTRONICS Again In The NEWS

In case anyone should have doubted it, the ever-increasing importance of electronics to the defence of the country was highlighted recently in the British aeronautical weekly *Flight*. A prominent and high-ranking R.A.F. officer was quoted as having said publicly that whereas the most advanced bombers of the last war carried radio and electronic equipment with a complement of 150 valves, the latest heavy bombers to go into service with the R.A.F. carry almost 1000 valves. This is a rather striking illustration of the extent to which modern fighting aircraft depend on electronic equipment for their very usefulness, and also of the strides that must have been made in a few short years in developing electronic instruments.

It might be argued that an illustration of this sort proves nothing at all, but we do not subscribe to this view. Many who served with the R.A.F. during the last war have a more or less complete knowledge of the various functions fulfilled by the equipments that went into, say, a Lancaster—navigational aids for a surprisingly wide variety of specific purposes, radar for target identification, accurate bomb release, identification of the aircraft itself to friendly ground radar stations, warning of the approach of other aircraft, and automatic aiming of defensive armament, communications receivers and transmitters, again for a number of specific purposes, and so on. All these functions were necessary at one time or another during the bomber's work, and indeed, caused a revolution in the effectiveness of such aircraft as a striking force. Moreover, if any single piece of equipment could have been dispensed with, it would have been, both because gear of this nature is expensive, and adds considerably to the cost of carrying on a war, and also because weight saved by carrying less ancillary equipment can be usefully employed in carrying a heavier load of bombs, or in adding range, by making it possible to lift more fuel off the ground.

If all these services which we have mentioned were provided by electronic gear to the tune of 150 valves, and were considered essential, surely the fact that a modern aircraft needs approximately seven times as much circuitry as this indicates that there has been a vast increase, not only in the number of functions that have to be performed electronically, but also in the importance of electronics in relation to the total effort.

Then again, just as aircraft themselves use vacuum tubes to a greater and greater extent, there is little doubt that on the ground, a modern air force will require an even more formidable radio and radar organization than it did during the last war. And when it is remembered that in the 1940s, the R.A.F. personnel engaged in communications and radar work were numbered in hundreds of thousands, the rather alarming question arises as to where are the trained electronics operators and mechanics to come from should another emergency arise. Certainly, every man whose peace-time job it is to know something of our own particular branch of applied science would be absorbed overnight, and with equal certainty, vast training schemes would have to be embarked upon forthwith.

We hope it will not be said that by treating a subject of this nature we are being pessimistic, or that we are warmongering. The fact is that the British Empire is already in the throes of a necessary and extensive rearmament plan, in the belief that in strength lies the greatest safety from aggression. While we, as civilians, can know nothing in detail of what might be required of us in the event of another war, we can at least see that our own particular sphere of endeavour is certain to be an exceedingly important one.

Thus it is that as responsible citizens, we could do worse than make it our business to learn as much as we can about the whole science and art of electronics. We may, for instance, have had no possible call to find out anything about the principles of radar, or of television, or of some of the fascinating electronic navigational aids that have so recently been developed. But should the dire necessity arise, then we will have to, by the compulsion of events outside our control. By taking to ourselves a new interest, in any particular branch of electronics that may take our fancy, we can not only augment our own knowledge, but we can also increase our potential usefulness to our country. It will be of little use if the British Empire equips itself with finer weapons than it has ever before possessed if in certain key branches of knowledge informed and trained personnel are to be so scarce as to prevent the best use from being made of those weapons. The electronic industry is undoubtedly one of those key branches, if not the most important of all; and that is why we, who already have some knowledge in this specialized field, can best serve our country and further the aims of the western democracies by learning as much more as we are able, particularly in parts of it that may be new to us personally, but which we know must have an important bearing on the defence of the realm.

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The "R. and E." 1951 Triode Amplifier

This new amplifier circuit is designed for those builders who want reasonably high quality without the dangers and difficulties attaching to modern circuits which use heavy negative feedback. Those who think that no amplifier that does not have negative feedback is worth while, will be agreeably surprised by the results they will obtain from this circuit, which is inexpensive and easy to build.

INTRODUCTION

Modern amplifier design seems to have reached a point where it is possible for anyone, with a little care in construction, to obtain results at least comparable with the best commercial standards.

This situation has come about through the use of very high-priced output transformers, of a quality and performance hardly even dreamed of a few years ago, together with the universal employment of amplifier circuits which make a feature of a high degree of negative feedback. With these feedback circuits, it does not seem to matter very much whether triodes or pentodes or beam tetrodes are used, as long as the amplifier is well designed, since comparable results seem to be obtainable with either.

But these modern developments are not all gain. The old saying that you can't get something for nothing is as true today as ever it was, and a substantial part of the price paid for the highest possible amplifier performance is the increased difficulty of ensuring that the amplifier really does have the performance we expect from it. To put it briefly, feedback amplifiers are harder to build than amplifiers without it. Many of us never stop to consider whether or not the difficulties involved in feedback amplifiers are worth it, probably because we naturally assume that what one man can do, so can another. This is only partially true, however, especially when the "one" is provided with expensive and comprehensive test equipment, while the other is not. In our opinion, many amateur constructors fail to build into their feedback amplifiers the quality that the circuit is capable of producing. Sometimes, no doubt, this is because the individuals concerned insist on making more or less random modifications to what, unknown to them, is really a fairly critical design, but often it is simply through lack of laboratory equipment, for which no one can blame them.

All of this brings us to the point we would like to make, namely that there is still a place for the amplifier of good quality, but using push-pull triodes WITHOUT negative feedback.

We ourselves, as well as everyone else, got along quite well in the days when the triode amplifier without feedback represented the best that a high-quality amplifier could do, and we are sure that very many of our readers will find the amplifier presented in this article fully up to their requirements for power output and fidelity of reproduction.

THE GENERAL SCHEME OF THE AMPLIFIER

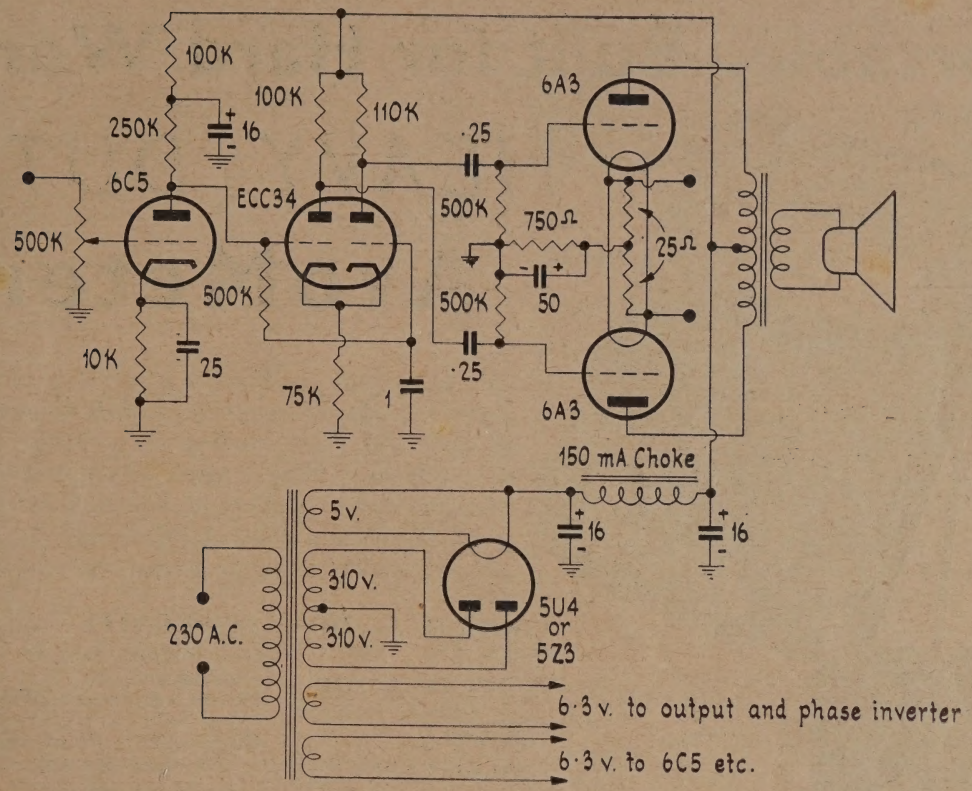
The amplifier is a very simple one, containing only four valves apart from the power rectifier. The first valve is a medium-gain triode voltage amplifier, using a 6C5 (or a 6C5-GT), and this is directly coupled to a double-triode phase inverter. This stage gives useful amplification as well as performing the phase inversion function, and supplies push-pull signals for the grids of the 6A3 output tubes.

The circuit arrangement of the first two valves is a little unconventional, but has been found to be an excellent one in all respects. The direct coupling between the plate of the 6C5 and the grid of the input section of the ECC34 eliminates one source of low-frequency loss, and is very similar to the first circuit of the well-known Williamson amplifier. There, the phase inverter was a single triode with equal load resistors in plate and cathode. This places the cathode at a high positive potential, so that it is not a difficult matter to arrange for the grid too to be highly positive, but a little less so than the cathode. Although the phase inverter used here is not the same, it has in common with the other circuit the fact that its cathode is at a fairly high positive potential. Because of this, direct coupling is possible here, too, and although on the face of things, the arrangement might appear to be critical as to circuit values, in practice this has not been found so, with the result that in spite of the direct coupling, no difficulty can be expected, even when ordinary wide-tolerance resistors are used. Indeed, it has been found possible to use almost any of the available small triodes in either position in the circuit without the slightest difficulty, the worst effect noticed being a slight variation in the maximum undistorted voltage output, although different values of cathode resistor for the first tube are needed for best results when either valve type was changed. In short, those who have not tried a direct-coupled circuit before need have no fear that they will not be able to get this one to work properly.

The input voltage required for full output from the 6A3s is about 0.5v. peak, into the first valve. The amplifier is thus eminently suitable for using after a radio tuner, and has ample sensitivity for handling the output of all but the very low-output types of gramophone pick-up available today.

CIRCUIT IN DETAIL

Since the voltage amplifier section will be a little unfamiliar to many readers, it would be as well if we described its circuit in a little more detail. The 6C5 has a high value of plate load resistor for a special reason. With 250k. as shown, it gives slightly more amplification than with the more usual 100k, but this is not the reason for the choice. If a high-value resistor is used in this position, the actual voltage at the plate of the tube will be considerbly lower than if a smaller load resistor were used. This is helpful in the present circuit, for the following reason. If the first grid of the ECC34 is very highly positive, as it will be when a small load resistor is used for the 6C5, steps will have to be taken to see that the cathode of the ECC34 also reaches a very high positive potential.. Indeed, the cathode of this tube must be a few volts more positive than the grid, for otherwise, the correct negative bias would not be there for the valve, and much distortion would result,



This being the case, then, only relatively few volts from the power supply are left to apply to the plates of the ECC34, and as a result, the undistorted output voltage would only be small, and might not be large enough to allow the 6A3s to be fully loaded. This is a situation to be avoided at all costs, so we make the load resistor on the 6C5 high, so that the voltage at the plate of the 6C5 is only about 100. For this tube, a low plate voltage does not matter, since it has to supply only a very small signal, of about 8v. peak, to the grid of the ECC34. This it can easily do with a plate voltage of 100. From this, we can see that the grid of the left-hand section of the ECC34 must also be at about +100v. with respect to ground. Then, in order that the ECC34 shall be properly biased, its cathode must be at approximately +105 volts with respect to ground, leaving a little over 200 volts as the effective plate supply voltage for the ECC34. This tube has to provide a peak signal of 50 volts for each 6A3 grid, but it can do this with some considerable output to spare given a supply voltage of 200 or over.

It will be seen that there is a decoupling filter of 100k. and 16 μf. in the plate circuit of the 6C5. This serves two purposes. First, it drops the plate voltage a bit lower still, and secondly, it acts as an efficient decoupler, preventing moat-boating, and also helping considerably in smoothing the H.T. supply for the 6C5. Builders should note that the value of this 100k. decoupling resistor should not be changed, because if it is, it will result in slightly changed operating conditions for the ECC34, and may, therefore, introduce distortion. Note also that the 16 μf. condenser should be a good one. There is no need to worry about its effect as long as it is a good one, but if it has excessive leakage, it will upset the bias on the ECC34. Those who are very fussy, or who cannot risk a breakdown through the possibility to this electrolytic giving up the ghost, would be well advised to use instead one of the excellent 4 μfd oil-filled paper condensers that can be had these days.

The next point worthy of mention is slight oddity of having unequal plate load resistors for the halves of the phase inverter stage. If both load resistors are equal, the outputs from the two halves of the tube will be slightly unbalanced, but this can be looked after by using the values shown on the circuit diagram. The 110k. resistor should be made up from a 100k. and a 100k. in series. There is no necessity for highly accurate choice of values, and stock resistors of these nominal values can be used. One advantage of this phase inverter circuit is that like the commonly used single-triode one, it does not in the least need a special balancing adjustment. The circuit can be wired up as shown, and then forgotten, in the certain knowledge that a nicely balanced input signal will be provided for the 6A3s.

The omission of the bypass condenser at the cathodes of the ECC34 is NOT a mistake. The circuit works because of its unbypassed cathode resistor, and if one were included, practically no signal at all would be given to the lower of the 6A3s. The 1 μf. condenser bypassing the lower end of the ECC34's grid resistor should be a high-quality paper one, and not an electrolytic.

The power supply is a very simple one, nor is it

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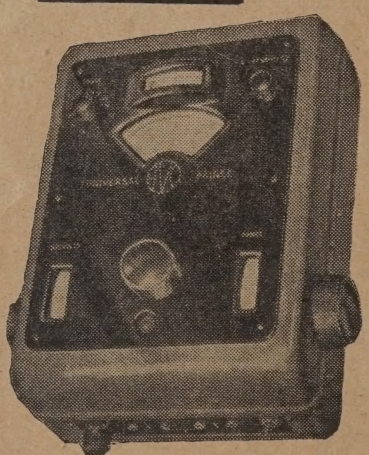

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expensive. The circuit itself discriminates strongly against hum, so that very elaborate filtering is quite unnecessary. A point to watch is that the ECC34 and the output tubes are both supplied from the same heater winding on the transformer. This puts the heater of the ECC34 at 50 volts, so that there is only a potential difference of 50 volts or so between its heater and its cathodes, which are at about 105 volts. This difference of potential is quite allowable, but if the ECC34 were fed from an earthed heater winding, the 105 volts at the cathode would exceed the maximum permissible heater-cathode voltage of 90 volts for this tube. In any case, it is always a good plan to run valves with as small a voltage between heater and cathode as possible.

CONSTRUCTION

We have not shown photogaphs or a chassis diagram of this amplifier since it is so straightforward that special layout of parts is not at all necessary. As long as the input tube is kept as far away from the power transformer as possible, and at the same time, close to the input socket, no trouble of any kind should be experienced. The valves can be placed on the chassis just as they are in the circuit diagram, with the power supply components in any convenient position as long as they are not too near the input end of the amplifier.

VALVE SUBSTITUTIONS

Some readers will no doubt wonder why we have not used a 6SN7 as the phase inverter, and the reason is simply that these tubes are in short supply at the present time. Those who have one may like to use it, however, and there is no reason why they should not. Moreover, tests have shown that no circuit changes are necessary. This, incidentally, shows how non-critical the circuit is. However, the ECC34 is preferable, since it gives a somewhat greater undistorted output voltage than the 6SN7, and we would recommend its use where possible.

British Companies and Australian Television

Although it is still uncertain when Australia will have television, three British manufacturers are planning Australian factories to make receiver sets in anticipation of the service. One of the companies is Scophony-Baird, Ltd., of Wembley, England, which will soon announce a tie-up with an Australian firm for the manufacture of 625-line television sets. The British company will send design engineers to assist in the early stages of the manufacture.

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VALVE NEWS

Mullard-American Interchangeable Types

In previous issues of "Radio and Electronics" we have given equivalents of American Valves, produced by MULLARD. These lists covered all receiving types and proved to be of tremendous value in replacing some of those "hard to get" American Valves. The following additional list of special industrial and receiving valves, directly replaceable by a MULLARD, will provide a useful and convenient guide when next you are faced with replacement problems.

American Type	Mullard Replacement	American Type	Mullard Replacement
0A4G	1267	6J6	ECC91
1A3	DA90	6N8	EBF80
1L4	DF92	6X2	EY51
1R5	DK91	12AT7	ECC81
1S5	DAF91	15A6	PL83
1T4	DF91	16A5	PL82
2D21	2D21	19W3	PY80
3A4	DL93	19Y3	PY82
3A5	DCC90	21A6	PL81
3NP4	MW6-2	807	QV05-25
3S4	DL92	829B	QQV07-40
3V4	DL94	866A	RG3-250A
5V4G	GZ32	1267	1267
5Z4G	GZ32	5544	MT5544
6AB8	ECL80	5545	MT5545
6AL5	EB91	5557	MT17
6AM5	EL91	5559	MT57
6AM6	EF91	5861	ME1001
6BE7	EQ80	FG17	MT17
6BX6	EF80	FG57	MT57
		FG105	MT105

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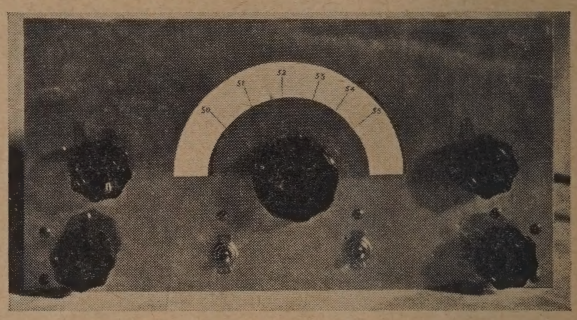
The "Radel" 6-Metre Amateur Receiver

Part II—Layout and Construction

In last month's instalment of this article a chassis diagram of the set, and a photograph of the above-chassis layout were featured. In the former, the front of the chassis is at the top of the diagram. A narrow strip of the chassis along the front is used for the signal and oscillator circuits. Three midget two-gang condensers are used, one for the aerial tuning, one for the mixer grid circuit, and one for the oscillator, in that order from left to right, looking at the chassis from the front. Two of these condensers are mounted underneath the chassis, and one above, and each is provided with a small 2 in. diameter drum on its shaft. The three condensers are ganged together by taking a cord drive round all three drums, continuously. Backlash is avoided by utilizing the three tensioning springs that belong to the drums, and the whole arrangement is driven by a small planetary reduction drive mechanism attached to the centre spindle of the middle drum. In the photograph the drums for the R.F. and oscillator tuning condensers can just be seen through the rectangular cut-outs made in the front of the chassis to allow the cord to pass through. The dial pointer is made from a piece of sheet aluminium clamped between the drum shaft and the drive shaft of the planetary mechanism. The pointer proper is a piece of fine wire crimped on to the upper end of the piece of aluminium. In the front panel is a semi-circular cut-out an inch wide, and stiff paper is fixed to the back of the panel to form the scale. The fine wire pointer is behind the scale, and its shadow is projected against the scale by a dial lamp which is mounted on the centre drum, and moves with it. Its position is directly behind the wire pointer, so that as the dial is turned, the lamp moves with the pointer, and stays directly behind it. A small tin reflector is soldered to the dial-lamp holder, and serves to produce a bright band of light centred on the pointer position at all times, while there is enough stray illumination to give a diffused glow over the whole scale. All this is a little trouble to make, but costs nothing, and results in a very fine dial that is at the same time something out of the ordinary. Looking at the photograph on last month's front cover, the three valves along the front of the chassis, nearest the panel, are the R.F. amplifier, the mixer, and the oscillator. Directly behind the mixer tube is the first I.F. transformer, and behind that again is the first I.F. amplifier tube. The circuit then progresses to the left through the second I.F. transformer, second I.F. amplifier (directly behind the visible tuning condenser) the third I.F. transformer and the second detector. Directly behind the second I.F. tube is the A.V.C. and first audio tube, V_8, and behind that again, the output valve. The large valve next to the power transformer is the rectifier, while the solitary tube near the back left-hand corner of the chassis is the B.F.O. tube. The smoothing choke is the one that can be seen on the photograph at the left-hand edge of the chassis.

The controls on the front panel are arranged as follows: In the bottom row, left to right, we have the variable aerial coupling control, the B.F.O. on/off switch, the stand-by switch, and the audio gain control. Above, at the left ,is the B.F.O. pitch control, in the centre, the main tuning control, and at the right, the I.F. manual gain control.

The under-chassis photograph shows the construction of the circuits quite clearly, with the coils mounted directly on the stator lugs of the tuning condensers. The two special neutralizing condensers, C_1 and C_2 on the diagram, can be seen partially obscuring the socket of the R.F. amplifier tube, since they are mounted directly on the grid and plate lugs of the socket. These condensers are made from ordinary Philips trimmers by filing off all the concentric cups, leaving only the fixed and adjustable base plate. These are used as a simple parallel-plate condenser, the mounting and adjusting mechanism of the trimmer being retained exactly as in the original condenser. This modification gives the condencers a capacity range of approximately 1 to 3 $\mu\mu$f., which is ample for the purpose, and which ensures that the correct neutralizing capacity of about 1.5 $\mu\mu$f. can be achieved. In order to allow the plates of the modified trimmers to come close together, the fixed plate is slid up the ceramic tube which forms the basis of the construction, simply by heating the thick wire which comes through the bottom of the tube, and then sliding the lower plate up the ceramic tube till it is without about a

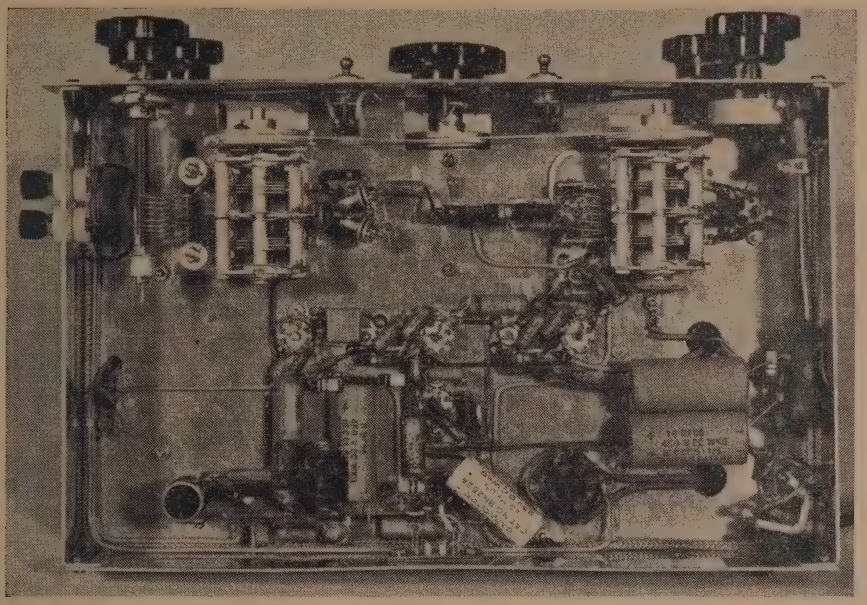


Showing front panel appearance of the receiver.

thirty-second of an inch of the moving plate, which has been previously screwed as far in as it will go. It should be mentioned that when modifying the moving plate of the condenser, the innermost ring should be left on, because this slides over the ceramic tube, and prevents side-play.

The wiring of the R.F. section should be carried out in as symmetrical a manner as possible, since the circuit is a balanced one, right up to the grids of the mixer tube. The 15 $\mu\mu$f. coupling condensers from the R.F. plates to the mixer grids are mounted right at the grid pins of the mixer, and leads are taken through small holes in the chassis to the near stator lugs of the R.F. plate tuning condenser. Note the positions of the coils in relation to the tuning condensers. All coils are mounted straight on to the stator lugs, but each condenser has two pairs of stator lugs, one on each side of the condenser. The R.F. tube, it will be seen, is mounted as closely as possible to the plate tuning condenser, so that the plate leads are very short indeed, up to the nearest stator lugs. Then, in order to avoid congestion, the coil is mounted on the lugs on the opposite side of the condenser, and nearest the mixer grids. Similarly, the oscillator tuning coil is put on the side of its tuning condenser nearest to the mixer socket, while the oscillator tube itself is on the opposite side of the condenser. In this way crowding is avoided, and yet no leads carrying R.F. are more than about an inch long.

The oscillator coupling condensers, C_{21} and C_{22}, are home-made from some 24-gauge tinned copper wire, and some short lengths of P.V.C. solid hook-up wire. Eighteen turns of the tinned wire are close wound over a small piece of the hook-up wire, and form a small condenser with the central wire acting as one plate, and the outside wire acting as the other. A short length of both inner and outer wires is left to act as a connecting wire for each plate, and the two condensers thus made are wired in with practically no lead length at all. These condensers can be seen in the photograph, one at each side of the oscillator coil.



Underneath view of the completed receiver. Two of the three ganged split-stator condensers can be seen. That on the left tunes the R.F. grid, and the right-hand one is the oscillator tuning.

The construction of the remainder of the set follows normal practice, and presents no difficulty at all. It is a good plan to use midget paper condensers, as we have done in the original, as these fit in well with the small size and close spacing of the miniature sockets.

OMISSIONS ON THE CIRCUIT DIAGRAM

Unfortunately, there have been one or two omissions made in the circuit diagram. These concern the fixed and adjustable band-setting condensers in the R.F. portion of the set. First of all, in the R.F. stage grid circuit, two 3–30 $\mu\mu$f. Philips trimmers are wired in series and connected across the stator lugs of the tuning condenser. This gives a maximum capacity of 15 $\mu\mu$f. which can be used when adjusting the tracking of the R.F. end. Similarly, across the R.F. plate coil is connected a single 3–30 $\mu\mu$f. Philips trimmer for the same purpose. Across the oscillator circuit there should be a fixed 15 $\mu\mu$f. ceramic condenser. None of these band-setting condensers have been shown on the main circuit.

A further, but less serious omission is the on/off switch for the B.F.O. This should be connected between R_{19} and the main H.T. line. The stand-by switch, which turns off the H.T. supply to all valves, while leaving all heaters running, is the unmarked one directly above the rectifier, V_{10}.

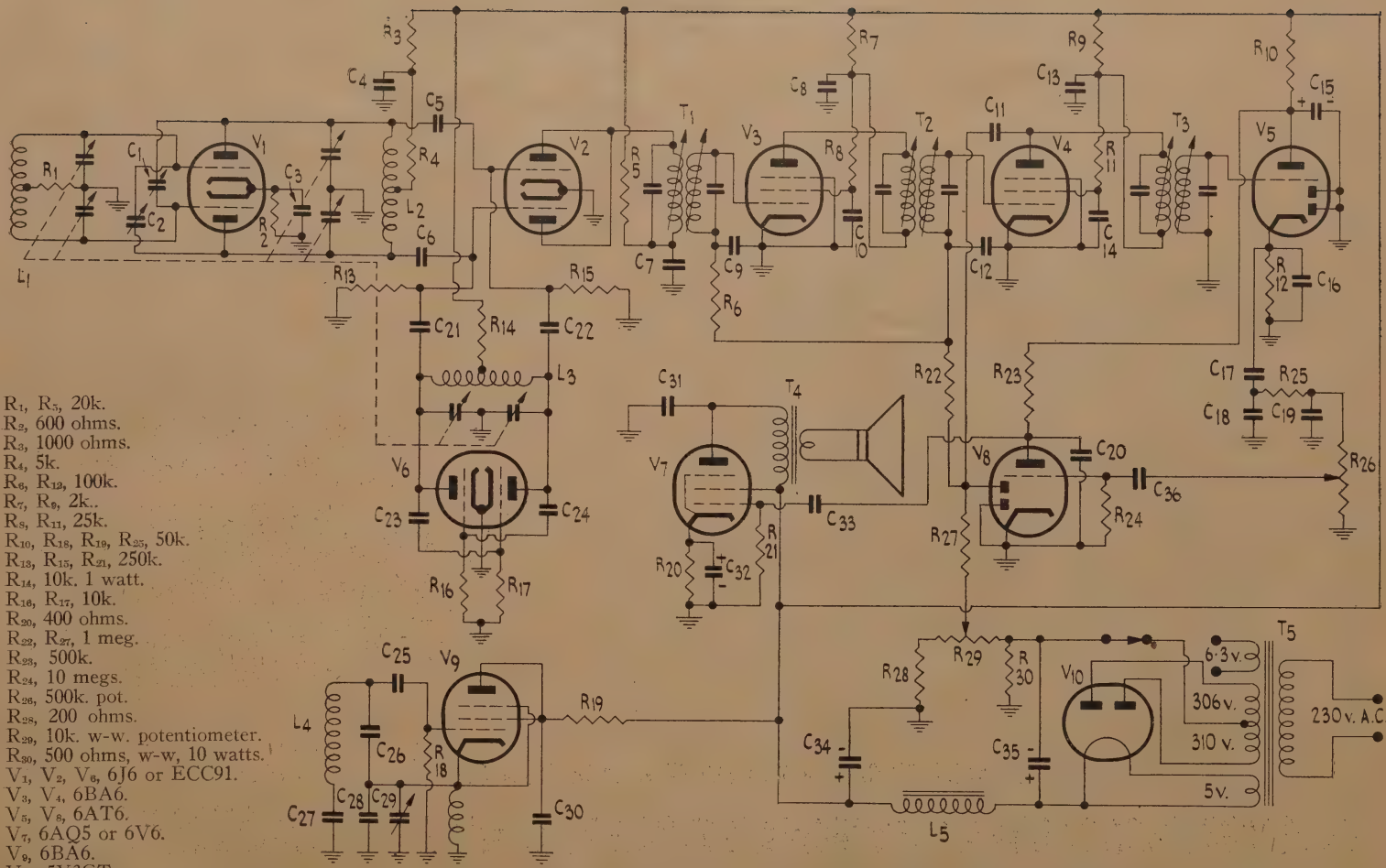
COIL DATA

The coils for the R.F., mixer, and oscillator, are all wound with 20-gauge tinned copper wire, to a diameter of 9/16 in. All occupy approximately an inch of winding length, which is adjustable for trimming purposes, simply by squeezing or stretching the coil slightly. The oscillator coil has seven turns, and the other two, six turns each. All are tapped at the centre, simply by soldering the lead of the appropriate resistor to the centre of the coil. The turns are widely enough spaced to allow this to be done quite easily.

INITIAL SETTING-UP

The first step after completing the wiring and checking it over for mistakes, is to align the I.F. stages. This is done in the conventional manner, from the detector backwards, using a modulated signal and an output indicator. The screws of the adjustable slugs are quite freely fitting, and it is a good plan to flow a little molten wax on to each thread to prevent shifting after the adjustment has been made. The circuits should be carefully peaked with the meter, rather than by ear, since at the 4.5 mc/sec. intermediate frequency, each adjustment is so broad that it is not possible, as at lower frequencies, to pick the correct point simply by listening for maximum output. This can be used as a rough initial adjustment, but the meter should defintely be used for final setting.

This done, the frequency range of the oscillator should be checked with an absorption wavemeter. With the coil and condenser specified, it will only be necessary to see that the oscillator frequency of 47.5 mc/sec. comes at or near the centre of the dial, since there is a quite generous overlap at each end of the dial. The only adjustment possible on the oscillator circuit is the coil inductance, since the fixed band-setting condenser will see that the tuning range is adequate. It is most unlikely that adjustment of the spacing of the coil's turns will not enable the right frequency to be placed at the centre of the dial. The oscillator is worked on the low-frequency side of the



R_1, R_5, 20k.
R_2, 600 ohms.
R_3, 1000 ohms.
R_4, 5k.
R_6, R_{12}, 100k.
R_7, R_9, 2k..
R_8, R_{11}, 25k.
R_{10}, R_{18}, R_{19}, R_{25}, 50k.
R_{13}, R_{15}, R_{21}, 250k.
R_{14}, 10k. 1 watt.
R_{16}, R_{17}, 10k.
R_{20}, 400 ohms.
R_{22}, R_{27}, 1 meg.
R_{23}, 500k.
R_{24}, 10 megs.
R_{26}, 500k. pot.
R_{28}, 200 ohms.
R_{29}, 10k. w-w. potentiometer.
R_{30}, 500 ohms, w-w, 10 watts.
V_1, V_2, V_6, 6J6 or ECC91.
V_3, V_4, 6BA6.
V_5, V_8, 6AT6.
V_7, 6AQ5 or 6V6.
V_9, 6BA6.
V_{10}, 5Y3GT.
C_1, C_2, modified Philips trimmers.
C_3, C_{26} 500 $\mu\mu$f. mica.
C_4, C_7, C_8, C_9, C_{10}, C_{13}, C_{14}, C_{36}, 0.01 μf.
C_5, C_6, C_{23}, C_{24}, 15 $\mu\mu$f. silvered ceramic.
C_{11}, 30 $\mu\mu$f. silvered ceramic.
C_{12}, C_{17}, C_{33}, 0.05 μf.
C_{15}, 8 μf. 450v. electro.
C_{16}, C_{18}, C_{19}, C_{20}, 50 $\mu\mu$f. mica.
C_{21}, C_{22}, 3 $\mu\mu$f. (see text).
C_{25}, 100 $\mu\mu$f. mica.
C_{27} $\mu\mu$f. silvered mica.
C_{28}, 250 $\mu\mu$f. mica.
C_{29}, 420 $\mu\mu$f. variable.
C_{30} 0.02 μf.
C_{31}, 0.002 μf. 750-volt.
C_{32}, 25 μf. 25v. electro.
C_{34}, C_{35}, 16 μf. 450v. electro.
T_1, T_2, T_3, 4.5 mc/sec. miniature I.F.T.'s
T_4, 5000 ohms to V.C.
T_5, power transformer, 310v. per side, 100 ma.
L_1, L_2, L_3, see text.
L_5, 100 ma. choke.
L_4, close-wound 28 en. wire, to length of $\frac{1}{2}$ in. on a $\frac{1}{2}$ in. diameter former.

signal, so that with the 4.5 mc/sec I.F., the oscillator frequency indicated above will put a signal frequency of 52 mc/sec. at the middle of the dial.

This done, the next step is to make a rough adjustment of the mixer grid coil and its band-setting condenser. The main point to watch is to leave the oscillator circuit severely alone, and work only on the mixer coil. The dial is turned to the centre position, and the band-setting condenser is tuned for maximum output on either a 52 mc/sec. signal, or else on ignition noise. This puts the circuit roughly in the right place. Next, the dial is turned to the extreme high-frequency end, and the condenser is re-set to give maximum output on either noise, or a signal on approximately 48 mc/sec. In doing this, it will be noted whether the condenser has to be screwed in or out from its previous setting. The tuning is then shifted to the low-frequency end of the dial, and a check is made, by adjusting the bandsetting condenser, on whether more or less inductance is needed in the coil. If the condenser has to be increased to restore resonance, the inductance is too small, and vice versa. Thus, we now return to the high end and re-set the condenser to its proper setting, since we have disturbed it in finding out about the coil. The coil is then adjusted in the direction indicated by the trial with the condenser, until a maximum signal is obtained. Returning again to the high end, the condenser is re-peaked. The coil is then adjusted a second time (at the low end of the dial, of course) and this time things should be very nearly correct, as tuning over the band will show. The whole process is exactly analagous to adjusting a broadcast set, using the trimmers to set the high-frequency end, and the padder at the low-frequency end, the only difference being that here we use the inductance to adjust the low-frequency end to resonance, instead of a padder. The above adjustments can be made with the R.F. tube either in or out of its socket, because a final fine adjustment will be made after the R.F. stage has been neutralized, in any case. If the tube is left in, then the grids should be short-circuited to ground in order to prevent oscillation, which would certainly occur before neutralization has been effected. An alternative is to disconnect the heater supply to the R.F. tube while the circuit is being adjusted. If this is done, little or no re-adjustment of the tracking of its plate circuit will be needed after neutralization has been carried out.

NEUTRALIZING THE R.F. STAGE

The best way to do this is to disable the R.F. stage by disconnecting its heater supply. The tube capacities to be neutralized are still present, and can be neutralized without fear of oscillation, since the tube is turned off. The trick is to attach an output meter to the set, and to adjust the neutralizing condensers for minimum output. The rest of the set thus acts as a sensitive neutralization indicator, since if perfect neutralization were obtained, no signal at all could feed through to the rest of the set if the R.F. stage is plugged in, but inoperative. The first step in the neu-

(Continued on Page 45.)

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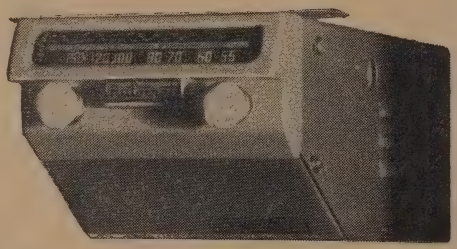

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Why Not "T" Attenuators—Part II

An Audio Frequency "Microvolter"

For those who are practically inclined, the next circuit is one which is easily made up, and which will serve to convert an audio oscillator into a calibrated signal source. It consists basically of the arrangement of Fig. 6, with the addition of a built-in cathode follower input stage, and an extra input section giving a small amount of attenuation, and acting as the permanent load for the cathode follower. Each section attenuated 10 times, and the 1000-ohm output potentiometer is calibrated from 0 to 10. If the oscillator can provide an output of something over 15 volts R.M.S., the cathode follower will give an output of just over 9 volts R.M.S., or 13v. peak. Then, if the first attenuator section gives an attenuation of 10/13, or an input/output ratio, A, of 1.3, there will be 10 volts peak signal at the output of the first attenuator section. On the next step of the switch, the maximum output will be 1 volt, and on the remaining two, the first of these formulae was the subject of an error, as printed, and should have read:

$$R_s = R_o \left(\frac{A-1}{A+1} \right)$$

BUILDING THE MICROVOLTER

The microvolter can easily be built into quite a small box, and it is recommended that the 6V6 cathode follower stage be included along with the attenuator proper. The resistors of the attenuator sections are mounted round the contacts of the switch which should be of the ordinary wafer type, the only wiring precaution necessary being to see that the leads from the output of each

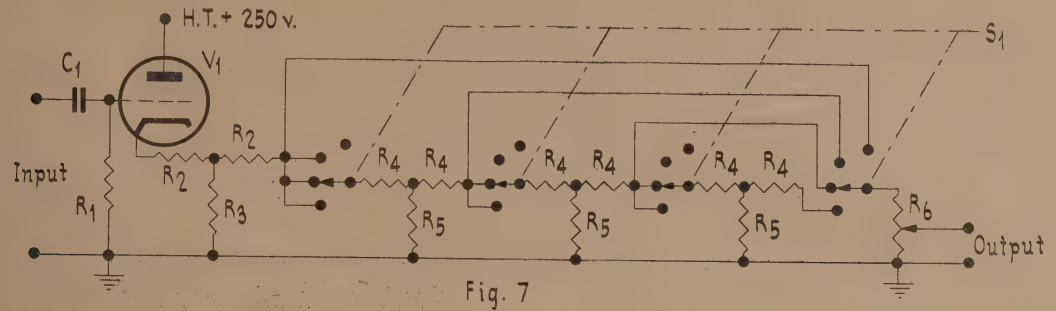

Fig. 7

0.1 volt, and 0.01 volt. If the potentiometer is calibrated with ten equal divisions, the smallest known output will be 0.001 volts, or one millivolt peak.

It is more convenient, as a rule, to have the output calibrated in terms of peak voltage, rather than R.M.S., since for most purposes the output will be supplied to an amplifier valve, and it is the peak signal voltage which determines whether the valve will overload or not. A good rule of thumb is that an amplifier valve will handle a peak voltage of about 1 volt less than the D.C. grid bias before grid current sets in, so that if we work in peak voltages, it is easy to estimate whether a particular valve is handling as much signal as it should before overloading. Only very low-level devices have an output smaller than one millivolt peak, so that the calibrated attenuator can be used to test almost any audio stage with an input signal similar to what it will in practice be called upon to handle. The calibrated attenuator has been called a "microvolter" for want of a better term, although the outputs it provides are certainly not as small as this. However, once the circuit is set up, there is no reason why the input voltage should not be dropped, when convenient, to a tenth of the normal, or 1 volt, so that outputs of known strength would be available down to 0.1 millivolt, or 100 microvolts.

Unless the available input voltage to the attenuator from the audio oscillator is known, it is not possible to specify the values for the first attenuator section, but these can easily be worked out from the two formulae given in the first instalment of this article. Incidentally, attenuator section to the output wafer of the switch do not approach each other any more closely than necessary. The purpose of this is to avoid direct capacity coupling between the high-level portions of the circuit and the output section. Since the 6V6 is run at a considerable plate current, quite an amount of heat is generated by the valve, and adequate ventilation should be provided so that the attenuator resistors will not get too hot, and change their values.

The most tedious job, but not a difficult one, is that of adjusting the resistors to the correct values, for stock resistors of the right values are not available. Luckily, for a job of this sort, we have to find a number of resistors of the same value, six of 820 ohms being needed, and three of 202 ohms. Luckily, the effect of small inaccuracies in the resistor values has only a slight bearing on the amount of attenuation obtained, and it is only necessary to choose values correct to about 5 per cent. to give a negligible attenuation error in the completed article. Most of the carbon resistors available these days seem to err on the high side, so that it is necessary to start off with resistors that are lower than the target value. This is because it is not possible to adjust the resistors to lower values than they already have. As long as all those to be used have lower values than are required, they can be brought up to the desired values by the judicious use of a hacksaw and a file. In our own case, we used resistors of nominal value 600 ohms. Since they were almost all higher than this, when measured, but lower than 800 ohms, it was a simple matter to adjust them.

ADJUSTING THE RESISTORS

It is, of course, essential to have some means of measuring resistance, before the resistor values can be adjusted. This means does not have to be a bridge, but can be an ohmmeter, or even a milliammeter and a battery. Since none of the resistor values are at all high, the common ohmmeter will be quite satisfactory for the job. The resistor to be adjusted can be gripped in a vice, between cardboard placed in the jaws to insulate the resistor and to protect it. Then, the ohmmeter or bridge is connected, and several slots are cut in the resistor with a hacksaw, measuring after every few strokes, so as to ensure that the desired value is not exceeded. If only a voltmeter and a milliammeter are available, a battery of known voltage can be used to measure the resistance by putting the resistor, the milliammeter, and the battery, all in series. Care should be taken, however, to allow for the D.C. resistance of the meter movement, which is usually marked on the face of the meter. For instance, if the resistor is to be brought to 820 ohms, and the meter has a resistance of 50 ohms, then the current to be sought by adjusting the resistor should be calculated on the basis of a resistance of 870 ohms. Even this neglects the internal resistance of the battery, but this can be neglected as long as an accumulator, or *fresh* dry cells are used for the battery.

USING THE MICROVOLTER FOR OTHER PURPOSES

Apart from the problem of applying known input voltages for testing amplifiers—which the microvolter solves directly—several other uses exist for such an attenuator. For instance, owing to the high input impedance of the cathode follower, it can be connected to any point on an audio amplifier as a means of sampling the signal voltage at that point. The only qualification in this case is that the signal at the point concerned must not exceed the voltage that the cathode follower can handle without introducing distortion itself. In the present case, this voltage is not particularly high, because with the 6V6 passing, say, 30 ma., it is not possible to have a negative peak voltage output at the cathode of more than 30 volts. The "gain" of the cathode follower circuit under these conditions is approximately 0.6, so that the peak input signal that can be handled is 50v. In practice, distortion will set in at something less than this input voltage, and for this reason, it is as well to either keep the signal input well down, or else to monitor the output waveform with an oscilloscope to ensure that distortion is not introduced by running the cathode follower at too high an input voltage.

At many places in an amplifier, the signal voltage is too high to apply all of it to the amplifier input terminal of an oscilloscope, and here the attenuator can be used as a convenient means of cutting down the voltage, without any risk of altering the frequency response, as often occurs when a simple potentiometer is used as a gain control at the input of the 'scope's Y amplifier.

The attenuator can be used also as a means of measuring the gain of amplifier stages. The audio oscillator is fed into the attenuator, whose output is first connected to the grid of the amplifier tube *following* the one whose gain is to be measured. A convenient output is obtained by adjusting the attenuator setting, and its value is read on an output meter, or as the deflection on a 'scope attached to the output of the amplifier. The attenuator setting is read and noted down. Then the attenuator is connected to the grid of the stage being investigated, and the output again adjusted until the *same output reading as before* is indicated on the 'scope or output meter. The attenuator reading is then taken again, and the gain is the ratio of the two readings. It will be noted that in performing this measurement, the attenuator is the thing that does the actual measuring. The output indicator need not be calibrated, since all it has to do is to act as an indicator, showing when two outputs are equal. The measurement is, therefore, independent of the accuracy or frequency response of the output indicator.

The reason why so many measurements are made in this way in engineering circles is that attenuators are inherently more accurate and stable in their performance than active things like meters or amplifiers. Once constructed and calibrated, they can be relied upon to hold their calibration for long periods of time, and thus to give reproducible and accurate answers over similarly long periods.

A point to note is that in measuring gain in this way, it is not necessary to know accurately the voltage applied to the input of the attenuator, since the answer is obtained simply as a ratio and this will remain the same whatever the input voltage, as long as it is the same for both parts of the measurement.

PARTS LIST FOF FIG. 7

C_1, 0.1 μfd.
V_1, 6V6, triode connected.
R_2, R_3, see text
R_4, 820 ohms
R_5, 202 ohms
R_6, 1000 ohm pot. (w.-w.)

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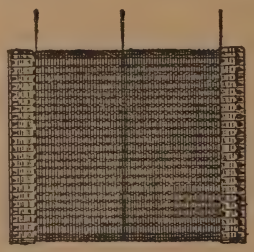

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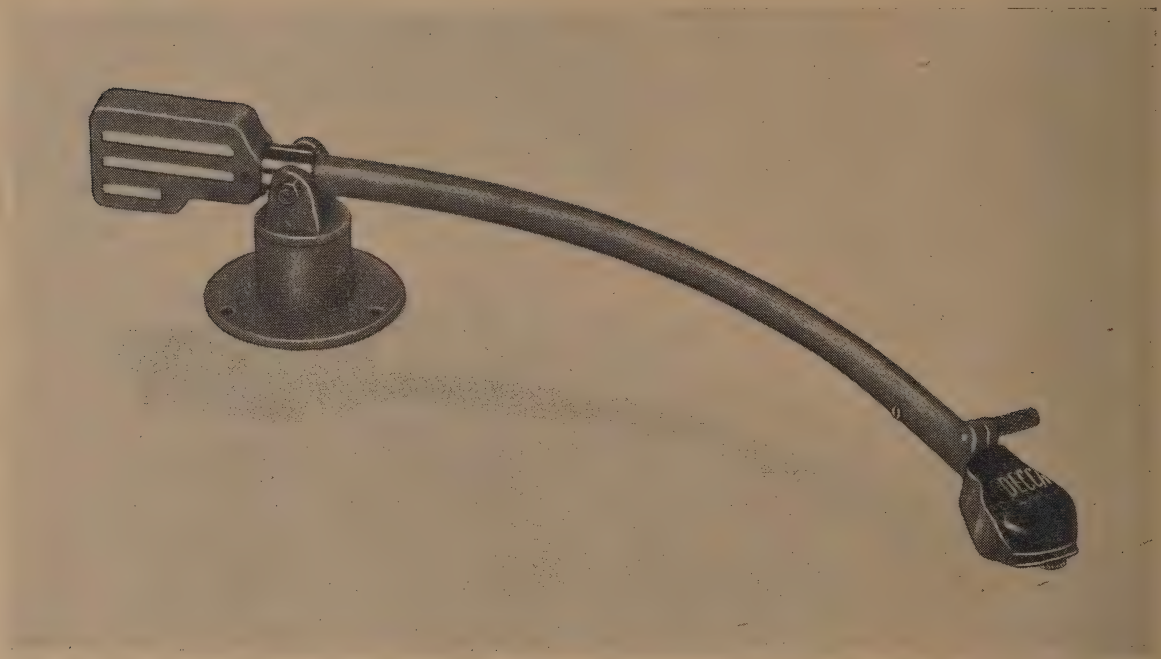

OUTSTANDING FEATURES OF THIS COMBINATION ARE—

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SHOES and SHIPS

"The time has come," the Walrus said,
"To talk of many things, . . ."

By Special Arrangement with the Walrus

THE VIBRATOR STORY

Every so often radio servicemen find that it is necessary to open up a vibrator for the sake of a minor adjustment because the exact replacement type is not available. More recently it has become necessary to resurrect every vibrator in the shop since the supply position is far from good and every one must be put into service if it is at all workable. Some vibrators are easily opened, a small spring circlip being used to retain the base in position, and when this is removed and the earthing connection to the other case unsoldered, the business part of the vibrator slips out easily.

The majority, however, are sealed into place by burring over the end of the shield can and this type poses a more difficult problem. True enough they can be opened by means of a pair of side cutters, and lusty leverings with a screwdriver, but then tinned bully beef has been opened by means of a bayonet before today! What has to be borne in mind is the

Fig. 1: Series Coil

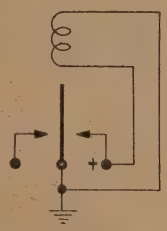


Fig. 2: Shunted Coil

fact that after repairs have been carried out, resealing is necessary in such a manner that the job looks reasonable enough to offer to a customer.

Firstly, a stout bladed pocket knife should be worked round the edge of the can to break the seal and start lifting the burred edge. Next a taper-pointed tool should be used to work the edge right up, and to this end an old screwdriver could be ground down to provide the necessary instrument. It should be shaped like a pencil point but not sharp, in fact, rather rounded at the point. With this tool it should be possible to open the vibrator right up and slip out the "innards" which may now be inspected for trouble. Two particular types of vibrator are in common use, one having a series coil and separate contacting arrangement, the other using two of the vibrator contacts to shunt or short-circuit the coil as shown in Fig. 2.

In the case of the series coil type the usual reason for non-operation is the failure of the coil contact to close through too fine adjustment. This is easily remedied by slacking the locking unit and advancing the contact a little.

The shunted coil type is usually quite reliable but if they have been left standing for some time the contact resistance increases (no doubt due to tarnishing of the contacts) with the result that the energizing coil is not completely shorted out. Thorough cleaning of the contacts is usually all that is required and a thin strip of very fine emery cloth drawn across them seems to be more effective than anything. While the contacts are still accessible it is a wise move to check the performance of the vibrator under actual operating conditions. When running under load in a properly designed power pack, little or no sparking at the contacts should be noticeable. However, if one set of contacts is sparking gentle pressure on the fixed contact so as to advance it towards the vibrating reed and then away from it will generally show in which direction it needs to go for

Fig. 3

smooth running. The amount of movement required is small and should not be overdone. If contact flashing is still present it is advisable to check the waveform of the transformer voltage to determine the correct value of buffer condenser to use. This will vary with different vibrators and transformers and while the theoretically correct waveform will not be obtained, at least more desirable results will be achieved. An oscilloscope should be connected to the transformer secondary and different values of buffer condenser tried, particularly with a view to eliminating destructive high peaks in the waveform.

Other irregularities may be tolerated but large peaks of an oscillatory nature can cause transformer breakdown and contact flashing since they may rise to many times the actual secondary voltage. Fig. 3A shows the most desirable waveform and Fig. 3B the effect of oscillatory peaks.

It is good practice to insert a 5k resistor in series with the buffer condenser across the secondary of the transformer since this limits the current that can flow and acts as a safeguard to the transformer should the condenser break down.

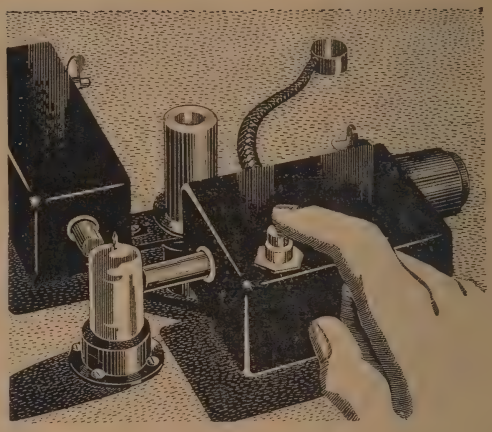
In sealing the vibrator back in its case make sure that the sponge rubber silencing pads are fitting nicely, particularly around the flexible connecting leads, and then push right into the can at the same time inserting the pronged base in position. Then roll the vibrator case around the edge to be sealed over, against a hard block, exerting plenty of pressure while doing so. Continue this rolling process until the edge is burred over as far as possible when it may be finally finished by tapping gently with a light hammer. If it is done carefully no further finishing should be necessary and you've saved yourself a vibrator!

Do you use the "R. and E." Photographic Service? For details see advertisements in previous issues.

WHAT "Reception-Tested" REALLY MEANS

Before they are carton-sealed, every Brimar Valve has passed with full marks 10 rigid and exacting factory tests—static, vibratory, dynamic, followed by heat treatment, and finally "noise and gain" examination in a test circuit.

Test illustrated here shows valves undergoing vibration tests. Hammers strike the valves alternately from directions at right-angles, whilst meters record the effect on valve characteristics. This ensures that each Brimar Valve will give long and continuous satisfaction under the most arduous conditions . . . perfect radio performance.



Some of the valve types available here in New Zealand are:

	R.F. Tubes	Mixer Tubes	I.F. Tubes	2nd Detector	Output Tubes	Rectifier Tubes
1.4v. Battery Types	1T4	1R5	1T4	1U5	3V4	—
6.3v. Loctal Types	7H7	7S7	7H7	7K7	7C5	7Z4
6.3v. Octal Types	6K7GT	6K8GT	6K7GT	6B8GT	6V6GT	5Y3GT
6.3v. All-Glass Types	6BA6	6BE6	6BA6	6AT6	6AQ5	6X4

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Ask your Brimar Representative for new display material.

THE "RADIO AND ELECTRONICS" ABSTRACT SERVICE

ANTENNAE AND TRANSMISSION LINES

General information on single conductor transmission lines, in particular one lines having a dielectric coating on the conductor, the dielectric making the boundary of the field. Such lines may have certain useful applications and suggest economy.

—*Proceedings of the I.R.E.* (U.S.A.), June, 1951, p. 619.

The possibilities of using excited aircraft wings, fuselage, and empennage as aerials has been investigated. It is possible to excite a wing by insulating and feeding the outer one-fifth of its length. For small craft the tip-fed vertical stabilizer proved easy to construct and suitable for some purposes.

—*Ibid,* p. 656.

AUDIO EQUIPMENT AND DESIGN

A substantial business has been built in the U.S.A. selling replacement "cartridges" for the pick-up arm. For those using the old fashioned stiff-acting cartridges designed prior to the arrival of microgroove records, the new cartridges are a boon and need replacement when worn.

—*Radio Television Electronic Service* (U.S.A.), June 1951, p. 20

In many string bands the instruments are now provided with amplifiers fed from microphones or pick-ups on the strings. The amplifiers are standard except perhaps for multiple inputs, and mixers are sometimes quite elaborate. Notes are given on servicing.

—*Ibid,* p. 22.

In recordings on disks there is one paramount factor—the groove dimensions, and the groove must make a firm mechanical contact with the tip. The depth must also be right, with contact below the top and no contact at the bottom of the groove. A loudness control for preserving all frequencies to a whisper is also described.

—*Ibid,* p. 28.

Properties of microphones which can be used in magnetic recording, with mention of the five types in use—microphone extensions, mixer pre-amps and the important question of recording direct without a microphone from say, radio.

—*Ibid,* p. 33.

Circuit diagram and description of the "Childs" amplifier which is built to the most critical standards and flat from 10 cps to 60 kc/sec. free from noise, and low output impedance. Uses 6SN7s and four 807s.

—*Radio and Television News* (U.S.A.), July 1951, p. 37.

It is important to consider radiation resistance damping at high frequencies and much experimental work is being done on the effect of the output impedance upon transients. Horn loading and the exponential horn are discussed.

—*Wireless World* (Eng.) July, 1951, p. 252.

Intermodulation distortions in gramophone pick-ups—intermodulation is the production of new components having undesirable sum and difference frequencies. The circumstances under which such arise in amplifiers are discussed.

—*Ibid,* p. 256.

CIRCUITS AND CIRCUIT ELEMENTS

If a cathode follower has a capacitive load its anode current may be cut off by a negative going input voltage of amplitude within the normal range. Such may occur in an ordinary amplifying stage without feedback, rather an unexpected development.

—*Wireless Engineer* (Eng.), July, 1951, p. 195

ELECTRONIC DEVICES

Some aspects of electrical computing—deals with problems of computing for such apparatus as anti-aircraft predictors, and shows methods of addition, multiplication, resolution of polar to cartesian co-ordinates and speed and acceleration measurements, also the computation of variable functions.

—*Electronic Engineering* (Eng.), June, 1951, p. 213.

Progress in electrometer valve (i.e., valves used for measuring of potentials) is reviewed with reference to the main question of stability. It is necessary that small changes in power supply voltage shall not affect the output and that a balance point should exist at or near the valve rating.

—*Ibid,* p. 217.

The Crompton Electrone, an electric organ which has unique features. The generators consist essentially of 12 rotating variable capacitors and the waveforms are engraved upon disks scanned by the rotors, so that a vast number of distinct tones can be produced. The instrument is stated to have astounding tonal quality and 'bite.'

—*Ibid,* p. 226.

A description of D.M.E. The aircraft transmits a train of short duration pulses which are received at the ground transponder and are shaped by suitable circuits to trigger pulses which are transmitted on a different frequency are received at the plane to give azimuth and distance measurements. As many as 50 planes may use the system without interference.

—*Proceedings of I.R.E.* (U.S.A.), June, 1951, p. 612.

An outline of fascimile picture transmission; the transmitter and receiver, methods of synchronism and operation.

—*G.E.C. Communications* (Eng.), Vol. 5, No. 2, 1950, p. 49.

The application of carrier telephony to open wire circuits has been restricted in the past to three or four channels. A description of 12 tested circuit carrier system for open wire lines. The voice frequencies are first translated to 60-180 kc/sec. range and two stages of group modulation are necessary. A full and interesting outline.

—*Ibid,* p. 57.

There are eight methods for the acceleration of electrons or ions, but most are ponderous and expensive. There is here proposed another method based on the transfer of the total magnetic energy of a moving electric charge to a small fraction of that charge, the device being an analogue of the hydraulic ram.

—*Wireless Engineer* (Eng.), July, 1951, p. 215.

Fractional horsepower motors. The problem of creating a starting torque in single phase induction motors is outlined with the methods of solving it.

—*G.E.C. Journal* (Eng.), April, 1951, p. 101.

Model makers will be interested in this control unit for a boat, which starts, stops, and reverses, steers and actuates a gun.

—*Radio and Television News* (U.S.A.), July, 1951, p. 49.

MEASURING INSTRUMENTS AND TEST GEAR

The electronic switch can be used in many applications, and it is possible with such to observe two waveforms on the one screen, such as the input and output of an amplifier. The multivibrator circuit for the instrument is given.

—*Radio and Television News* (U.S.A.), July, 1951, p. 32.

Navigational aids and other devices require the accurate measurement of phase differences but an absolute standard is lacking. Thus it is necessary to build a calibrator which is fundamentally accurate and such an instrument is described.

—*Wireless Engineer* (Eng.), June 1951, p. 197.

MATERIALS, VALVES, AND SUBSIDIARY TECHNIQUES

Transistors are promising for trigger circuits, which would greatly enhance their usefulness. They have extremely small RC time constants which makes possible fast rise times and high repetition rates. Small physical size, low operating voltages and the absence of stand-by power requirements are also attractive features.

—*Proceedings of the I.R.E.* (U.S.A.), June, 1951, p. 627.

A thrytron desideratum is the reduction of the time needed for the recovery of the grid control following the interruption of the discharge. Grid emission leads to unstable control characteristics and the overcoming of this disability is discussed.

—*Ibid,* p. 636.

One of the most versatile newcomers to the growing list of photo-electric traducers is the germanium photo-cell. This is especially adapted for trigger devices with output power high enough for useful work, which obviates amplifiers in the next stage.

—*Electrical Engineering* (U.S.A.), June, 1951, p. 518.

Metallic Rectifiers—the designation of polarity in diagrams confuses many, also problems of reverse current ratings. Life-ageing of the rectifiers, A.C./D.C. voltage ratio and the relative advantages of different kinds of stacks here explained.

—*Radio Television, Electronic Servicing* (U.S.A.), June, 1951, p. 27.

MATHEMATICS

A new theory for the resolution of a modulated signal into its radio-frequency spectrum is presented. A major difficulty has been the transition from the instantaneous frequency concept to the spectrum solution which is resolved here and the concepts apply to any type of modulation.

—*Proceedings of the I.R.E.* (U.S.A.), July, 1951, p. 648.

PROPAGATION

Many problems involving the transmission of electro-magentic waves can be solved very elegantly by making use of the impedance concept which reduces the field problem to a transmission line problem, and this is simplified again by working in terms of reflection co-efficient. The question is dealt with mathematically for eliptically polarized antennae.

—*Ibid,* May, 1951, p. 533.

Radio field intensities observed at distances considerably beyond the line of sight have been found to be much higher than would be expected. RF energy will attenuate less rapidly with distance if the polarization of the source of power is horizontal.

—*Ibid,* June, 1951, p. 643.

TRANSMITTERS AND TRANSMITTING

A review of three possible methods of measuring adjacent band radiation characteristics of transmitters is given and may be termed the two tone, normal signal, and thermal noise methods. It is the radiation just outside the permissible band which is difficult to suppress and the latter method is superior in eliminating this.

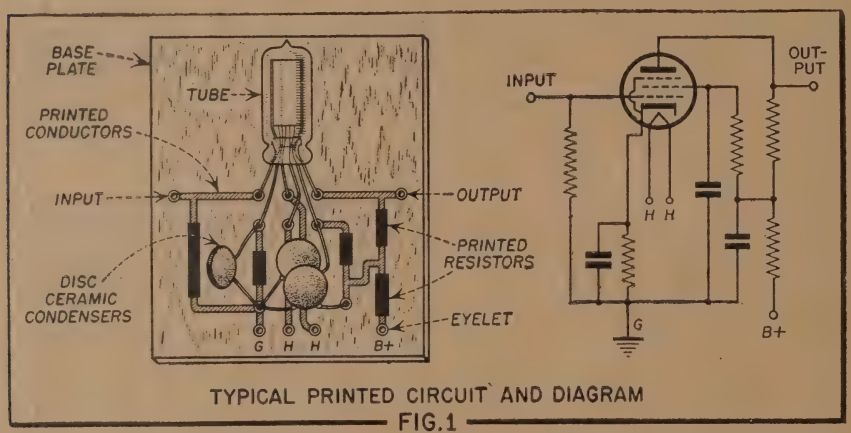
—*Ibid,* p. 653.

(Continued on Page 48.)

Printed Electronic Circuits

By the Engineering Department, Aerovox Corporation

The reproduction of electrical circuits on insulated surfaces by various printing techniques has become a standard method of fabricating small, lightweight, economical electronic devices. The increased emphasis placed by the Armed Services and industry on miniaturization and ruggedness of electrical components has caused this innovation to assume vital importance. Printed circuitry is no longer confined to a few military devices and hearing aids, but may now be encountered in a large number of everyday equipments. These include speech amplifiers, portable receivers, citizens two-way radios, television receiver front-ends, FM receivers, and many others. For this reason, a working knowledge of the design, production, and maintenance of such circuits will be a valuable asset to any worker in the electronics field. This issue of the "Aerovox Research Worker" is concerned with a discussion of the general types of printed circuits, the relative advantages of each, and methods of effecting servicing repairs.



TYPICAL PRINTED CIRCUIT AND DIAGRAM

FIG.1

The use of printed circuitry has been revolutionary not only because it permits the fabrication of extremely small and rugged electronic components, but also because it reduces the production of such components to a simple, rapid operation which is almost completely devoid of the possibility of human error. By this method, a relatively unskilled operator can reproduce literally hundreds of complex units in the time formerly required to make one unit by old-fashioned "wire-by-wire" soldering techniques. In addition to electrical conductors, critical circuit components such as resistors, capacitors, and inductors can be "printed" into the circuit in the same operation and held to close, reproducable tolerances. Fig. 1 shows a typical printed circuit and its schematic diagram.

Printed circuits are classified according to the method used to reproduce them. There are, at present, six general types. These processes are: painting, spraying, vacuum evaporation, chemical processing, metal stamping, and powdered metal dusting. Each of these general categories will now be discussed in some detail.

PRINTING TECHNIQUES

Probably the most widely used process for producing printed circuits is the *painting* technique. In this method, the conductors and other components of the circuit being fabricated are painted on the insulating surface which acts as the base for the circuit. The paint may be applied by hand with a brush, although in production operations the silk-screen stenciling process is more frequently used. Thin ceramic or plastic sheets may be employed for the base, or a metallic surface covered with an insulating lacquer may be used. In special instances, the glass envelope of a vacuum tube has been utilized as a base for its associated printed circuit. See Fig. 2.

The paint used for electrical conductors consists of a powdered metal such as copper or silver in suspension in a liquid binder. This conducting paint is applied to the surface of the insulating base to form the "wires" of the circuit. Other paint, made up of a resistive material such as carbon, may be applied in specific amounts to form resistors. Capacitors may be made by printing the plate on opposite sides of the base plate, if the required capacitance is small. Otherwise, small capacitors (such as the Aerovox Hi-Q BPD type disk ceramic) are connected to the printed circuit as in Fig 3. It is interesting to note that these capacitors are manufactured by processes which are essentially printed circuit techniques. Inductances are produced by painting spirals of conducting paint on the surface of the ceramic or other base material. "Cross-overs" in the wiring are made by painting the surface of the ceramic or other base material. "Cross-overs" in the wiring are made by painting one conductor directly over the other with a layer of insulating material such as lacquer between, or by "detouring" one conductor to the other side of the plate for a short distance by means of metal rivets or eyelets through the insulator, as is illustrated in Fig. 4.

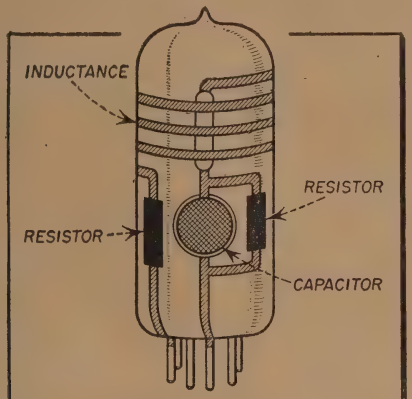
When all printed components have been painted in place, the entire assembly is "fired" at an elevated temperature to fuse the metal particles together and bond the circuit to the base plate. Temperatures ranging from room temperature for plastic bases to as high as 800 degrees C. for ceramics are used.

Vacuum tubes, external leads, and other components not printed are soldered to eyelets in the base plate as in Figs. 1 and 3. To take maximum advantage of the space-saving properties of printed circuits, tubes of the subminiature type are usually employed.

The painting technique has the advantage of requiring a minimum of auxiliary equipment and so has

been the most popular type for experimentation and design work with printed circuits. It is also the best method to use in making repairs on printed circuits, as will be discussed later.

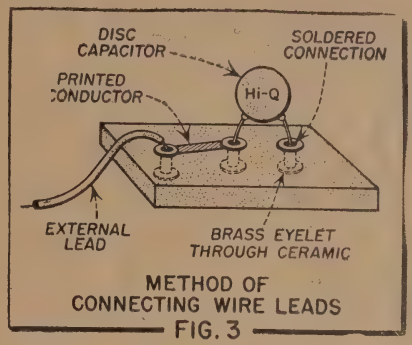
The *spraying* method of reproducing printed circuits differs from the painting technique in that the conductors are sprayed onto the surface of the base. Both molten metals and metallic conducting paints may be applied in this manner. In some processes, stencils are used to define the circuit conductors. In others, grooves are machined or moulded in the base material where a conductor or other circuit component is desired. Grooves may also be formed by sand-blasting through a stencil. Metal is then sprayed over the entire base plate, filling the grooves and covering the spaces between. The surface is then milled off, removing the excess metal and leaving only that in the grooves. High conductivity is obtained by this method since relatively large conductors are formed in the grooves. Standard tube sockets and other components are sometimes connected to sprayed circuits by mounted them on the opposite side of the base plate so that the terminals protrude through holes into the grooves. Then, when the circuit is sprayed, connections are automatically made to the conductors. Circuit cross-overs are made in a manner similar to that employed in the painting process. Resistors, capacitors, and inductances may also be formed by spraying.



PRINTED CIRCUIT ON TUBE ENVELOPE
FIG. 2

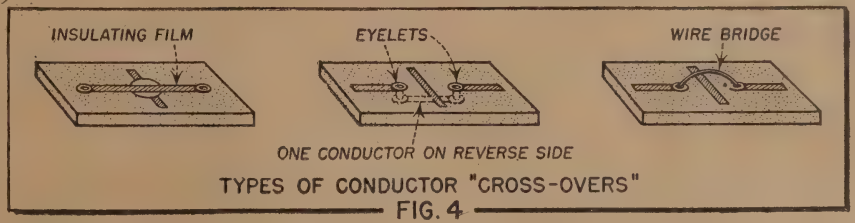
The *vacuum evaporation* process of circuit printing consists of evaporating a metal such as silver, copper, or nickel onto the surface of the dielectric by melting the metal in a vacuum. A mask or stencil on the surface of the insulator is used to outline the circuit desired. In one such process, called "cathode sputtering," a high voltage is applied between the source of metal vapour (the cathode) and the work upon which it is to be deposited (the anode). The metal vapour is thus drawn to the work by electrostatic forces. Only a "rough" vacuum, such as can be produced by a good mechanical vacuum pump, is required for this process.

Another vacuum process used is very similar to cathode sputtering except that no voltage is applied between the cathode and the work. Metal evaporated from a heated filament, or other source of metal vapour, is distilled on the printed circuit plate placed over it. In either type of vacuum processing, it is unnecessary to further heat treat or fire the deposited metal. Only thin films are usually deposited in this manner. If greater conductivity is required, conductors may be built up by electroplating.



METHOD OF CONNECTING WIRE LEADS
FIG. 3

In the *chemical-deposition* methods of making printed circuits, the techniques employed are similar to those used in silvering mirrors. A silvering solution, consisting of ammonia and silver nitrate mixed with a reducing agent, is poured on the chemically clean surface to be coated. The confines of the solution are controlled by an adhesive stencil. The metal films obtained are usually too thin to permit direct soldering, but may be built up by repeated coatings or by plating. The chemical processes have not been applied as extensively as those discussed above.



TYPES OF CONDUCTOR "CROSS-OVERS"
FIG. 4

The *metal stamping* technique has been used principally to print loop antennas on the back covers of radio receivers. However, other types of circuit wiring have been produced by this method. A die, bearing the outline of the desired circuit, is used to press a thin metal foil into the surface of a plastic or other insulator. In the same operation the sharp edges of the die cut the metal sheet to the desired shape. The metal sheet may be backed by an adhesive to ensure a good bond. Circuits made in this manner have good conductivity.

The last general type of printed circuit is produced by a process known as "dusting." In this method, a powdered metal is dusted onto the insulating base plate and fired in place. The circuit outline is defined either by coating the entire insulator with a sticky substance and applying the metal powder through a stencil, or by applying the bonding substance through the stencil

(Continued on Page 48.)

THE N.Z.E.I.

NEWS LETTER

Headquarters News

Following on the annual general meeting held recently, arrangements have now been completed to hold the first council meeting at which officers for the ensuing year will be appointed. Business to come before the meeting in addition to the normal routine business includes applications for membership approved by the Admissions Committee for two Associate Members, four Associates and five Students, so it would seem that interest in the Institute movement is quickening throughout the Dominion, particularly in view of the fact that many applications for copies of the Institute brochure describing the functions of the Institute have been received.

Subscriptions

Since the appeal in the September issue for payment of subscriptions several current subscriptions have been paid, but there are still some members who are unfinancial. Members are aware that it is necessary for the Institute to purchase *Radio and Electronics* on their behalf and send it to them and we would, therefore, appeal to all who have not paid their subscriptions to do so promptly.

BRANCH NEWS

Christchurch

On 7th August last a meeting of members was held at Station 3YA, Gloucester Street. Mr. T. C. Agar spoke on the Principles of Magnetic Tape Recording and a practical demonstration of the equipment was given which was appreciated by all who attended.

Dunedin

Recently Dunedin members gathered together to transact routine business and to hear a lecture by Mr. A. S. Pottinger, B.Sc., Grade I Chemical Engineer, and operator of ZL4GP. The subject for the evening was entitled "The Ionosphere, Sunspots, and Planetary Control and Interference." Mr. Pottinger deserves great credit for the way in which he presented his lecture, for his lucidity and informal style made it very easy for those present to assimilate the details of the lecture. Right from the beginning the lecture was very easy to follow due to his grasp of the subject and the unusual slides which he showed illustrating various points.

After a detailed explanation of the ionospher layers and their effect on radio transmission and reception, illustrated with a group of well selected slides, Mr. Pottinger then discussed sunspots.. Again he showed a series of well selected slides and listeners were able to understand the terrific powers unleashed by this solar activity. The puny size of the earth compared with the sun was effectively shown as a side issue. The cyclic rise and fall of sunspot activity was also referred to and Mr. Pottinger explained the intense effects of sunspots in the central zone of the sun's surface as compared with those towards the periphery. The slides dealing with this phenomena illustrated only the Northern Hemisphere as similar observations have not yet been made in the Southern Hemisphere.

The next portion of the lecture dealt with planetary control and interference. With slides demonstrating the mass and positions of the planets at various times he then proceeded to advance what seems to be a new approach to this proposition, which is that radio conditions are affected by the positions of the various planets at various times, *e.g.*, in conjunction and otherwise. As was to be expected this theory provoked considerable interest giving those present much food for thought. After some discussion on this subject the lecture concluded and members were unanimous in their approval of what was one of the most interesting lectures heard for some time.

Wellington

As we go to press, advice has been received that the next monthly general meeting of Wellington Branch will be held on Thursday, 13th September, when an address will be given by Mr. G. J. Burtt, B.A., on the Decca Navigator. This should prove to be an interesting address by one well versed in his subject.

Additions to Branch Library

(a) *Radio and Electronics,* Vol. 6, Nos. 3 and 4 (June and July, 1951).

(b) Philips Experimenter Nos. 40, 41, and 42.

(c) Philips Electronics Measuring Vol. 3, No. 4. Measuring vibrations in laboratories.

(d) Philips Anniversary Bulletin.

(e) Philips Electronics Application Bulletin. Television Optics, Part 3.

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RADIO COURSES

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A Few Thoughts About Pick-ups and Their Behaviour

The Text of a Lecture delivered to the Christchurch Branch of the N.Z.E.I. by

Mr. S. P. Willis, a Technician at 3YA

Few people know that an Irishman is credited with having conceived and made the first sound recorder. E. L. Scott, resident at the time in France, made an apparatus consisting of a diaphragm, stylus, and a moving recording metal plate travelling under the stylus at constant speed, for the study of the waveform of speech. The year was 1857.

A French physicist, Charles Cros, in 1877, proposed to modify this equipment and use it for playback, but Edison made and demonstrated a working machine three months before Cros turned his idea into reality. Both men were engrossed with the "hill and dale" method. Incidentally, Edison could think of nothing more important than the words "Mary had a little lamb" for his first record! Edison stopped work on his idea to concentrate on another project, electric lighting, and in this interval, a naturalized American of German origin, Berliner, scored with his development of the flat shellac disk, with lateral recording and the spiralled groove; he patented it as an "improvement" on Edison's patent, and his disks closely resembled present-day records. Berliner made and sold recordings complete with a talking doll, whose facial movements were synchronized thereto. No very worthwhile improvements occurred from then until 1926, when the British recording companies commenced electric recording. The electric pick-up was a relatively simple development of the telephone headpiece. What did the trick of capturing popular interest in records was the great improvement in microphone-amplifier technique, which is not in the scope of this present talk.

A magnetic pick-up has three elements, *a stylus* to link recorded sound in the groove with *the transducer,* which converts mechanical energy to electric energy, and *an arm* or other means of holding the assembly in position. The importance of the stylus is often overlooked.

First, consider the record groove, in which the stylus must ride, and at the same time accurately trace a course over each and every indentation of modulation in the sidewalls. It is clear that a 78 r.p.m. record (with 90 to 120 grooves to the inch) a groove width of 2.7 mm., will play properly only with a stylus which fits the groove sidewalls, yet clears the bottom of the trough, and also has a clearance at the trough edges. Thus a 1 mm. stylus would have an impossible job to do in the same groove. This is why a microgroove stylus cannot be interchanged with an ordinary stylus, and maintain high-fidelity standards and why interchangeable heads are necessary.

STYLUS WEAR

Point pressure in a groove adds up to tons per square inch. With wearing of the jewel, contact area increases, rate of wear decreases; the stylus changes its shape, and once the facets are a critical size, the "highs" begin to be unplayable, if their wavelength is shorter than the width of the facet worn on the stylus. Abrasion means groove dust, which is itself an abrasive, and the recording is quickly ruined; for these reasons a soft stylus is no answer to the problem either.

Looking at the mechanics of the microgroove stylus, a little study indicates that the rate of wear of stylus and record will be about three times as great as that on a standard record, despite the reduction in the vertical force necessary to keep the stylus tracking in the groove. It would seem that a hard jewel or diamond stylus is the only answer, and practice proves this contention, particularly as the L.P. records are cut at 208 grooves per inch!

THE TRANSDUCER OF "HEAD"

Without very special design, the popular Rochelle salt "bimorph" crystal pick-up head does not suit hi-fidelity requirements, due to a non-uniform response curve, being about 6 db. up in the 200–600-cycle area, and with rapid top "fall off" to 7 or 8 kc/sec.

Non-uniformity defies compensation, though the response curve can be improved with an equalizer.

Magnetic high-fidelity pick-ups are superior all-round and mechanically robust, even though pre-amplification is needed. With an equalizer, compensation for both record-characteristics and those of the P/U pick-up, results in first-class reproduction from 35 cycles to over 10,000 cycles.

DEFINITIONS

Non-uniform Response Characteristics; or Response Distortion

(a) This is when different frequency components emerge from the circuit with relative amplitudes different from those of the original wave. A variation of 3 db. is noticeable to the ear.

(b) *Non-linear Distortion* is when frequencies not present in the original wave appear in the output. Cause: Non-linear circuit elements or non-linearity in the transducer.

(c) *Phase Distortion* is when component frequencies emerge from a circuit with mutual phase relations different from those of the original wave. It is considered unimportant in audio work except when long landlines link equipment and is reduced to terms of network delay. Response distortion changes the timbre of speech and music, reduces intelligibility of speech and enjoyment of music. Loss of highs wipes out harmonics which identify instruments—*e.g.,* a violin sounding like a flute; loss of lows ruins true bass.

THE SUPPORTING ARM

This must (a) provide the proper vertical force (between 6 and 14 gms) for the stylus, and (b) provide lateral tracking across the disk at an angle as close to 90° to the groove as possible. It must also be adjustable at its pivot for height, and generally be counterweighted behind the pivot as well as free to rise and fall vertically without side play and with minimum friction in both planes.

An equalizer is an adjustable network of inductance or resistance and capacity, which compensates for non-linear characteristics of both pick-up and record.

Because of mechanical and space limitations of the groove, records are made with the frequencies below 300 cycles, cut at constant amplitude. There are two ways of making lateral records, constant amplitude and con-

(Continued on page 27.)

The PHILIPS Experimenter

No. 48: About Single-Sideband Suppressed-Carrier

In the later months of 1947, "ham" radio "discovered" single-sideband transmission of speech. The inverted commas are used advisedly, because the technique of transmitting speech as a single sideband, with the carrier, and the other sideband completely suppressed, is one which has been used for many years in wired telephony, and, indeed, is the principle which makes carrier telephony possible. Up till the time of which we are speaking, even the best technical brains in the amateur world had considered that the difficulties associated with the generation and reception of single-sideband transmissions were such as to make the scheme unfeasible for amateur communication. It took the initiative and foresight of a small group of American amateurs to prove, quite conclusively, that single-sideband could easily be put into amateur operation, and that, in practice, it possesses considerable technical advantages, very much in line with what the theory would predict for it.

WHAT IS BEHIND THE IDEA?

Before going on to give some idea of how single-sideband transmission and reception can be effected, it would perhaps be as well to outline the ideas which led up to the original decision to give it a try. These ideas indicated that the system would confer very considerable advantages not only on the individual amateur, but on the "ham" world as a whole. Moreover, indications were that the more widespread its use, the greater advantage to the larger number of people. We who devise and present the Philips Experimenter are convinced that the advantages are there, that they are substantial, and that by publishing practical and constructional information in subsequent issues of the Experimenter, the Philips organization will be doing a real service to the amateurs of this country.

At the outset, we should clarify what we mean by single-sideband-suppressed-carrier, or S.S.S.C., as it is usually abbreviated.

In ordinary A.M. transmission, the output of the transmitter consists not of the single frequency which starts off in life as the original unmodulated carrier, but of a band of radio frequencies. In the simplest case, namely that of a modulating signal which is a single tone, the output consists of three frequencies—the carrier, and the two side-tones, which frequencies are $(f_c + f_m)$ and $(f_c - f_m)$ respectively. Now in a case like this, the transmitter's voltage output at the carrier frequency is always the same, irrespective of the percentage of modulation, while at 100 per cent. modulation, each side frequency has a voltage equal to *one half the carrier voltage,* and less in proportion at lower modulation percentages. Thus, the *power* sent out by the transmitter is divided up as follows: Assuming a 100-watt carrier, the carrier power is 100 watts at all times. At 100 per cent. modulation, each side frequency has a power of one quarter of this, or 25 watts, so that the total power of the side frequencies is 50 watts, or exactly one half the carrier power.

This is a situation that has been accepted, in the past, as something that cannot be avoided. The carrier, as its name implies, is there only for the purpose of being modulated. In itself, it does not carry any of the intelligence we wish to convey to a distance, and yet, in our A.M. transmitters, it comprises 2/3 of the total R.F. energy transmitted. Only the side frequencies carry the information contained in the transmission, so that if some means can be devised of dispensing with the carrier, and and using the power output that the final amplifier will give, only for transmitting the side-frequencies, then a considerable saving should be effected at the transmitter. Now although we have illustrated the relationship between the carrier and a modulation consisting of a simple tone, the same things apply when the modulation is a complex audio wave derived from and representing speech or music. The only difference is that in these cases, the modulation frequencies are spread over a band on each side of the carrier frequency, and extending to frequencies of $f_c \pm f_m$, where f_m is now the highest audio frequency to be handled by the system. As long as the carrier is modulated 100 per cent., the voltage and power relationships given above still hold.

To continue the story, it is quite possible to transmit the sidebands of an A.M. signal, suppressing the carrier. This could be done either by using a highly selective filter which would remove the carrier, or by performing the modulation in a balanced modulator, which has the useful property of producing the sidebands, and balancing out the carrier so that it does not appear in the output. If this were done, *all* the transmitted power would be used for transmitting "intelligence" and the same final amplifier would be able to turn out more powerful sidebands than it did before, since the sidebands could now be brought up to the maximum amplitude that the tube will handle, instead of only half this figure, when the carrier is present. Unfortunately, although such a signal would be very easy to produce, it could not be used for communications purposes. The reason is not that it could not be transmitted, or picked up in a receiver, but that it would be almost impossible to obtain any intelligence from it, once received. In order to see why, it is necessary to look for a moment at the process of detection. One way of regarding detection that is very helpful in dealing with S.S.S.C. and similar phenomena, is to look upon it as a process of frequency conversion. Take our tone-modulated A.M. signal once more, and let us suppose that the modulation frequency is 1000 c/sec., and the carrier, 4 mc/sec. The received signal consists of three voltages. One at 4 mc/sec., one at 4001 kc/sec., and the other at 3999 kc/sec. When these three frequencies are applied to a detector circuit, the output will consist, among other things, of all the possible sum and difference frequencies that can be made from the three original frequencies. Of these, the ones we are interested in are 4001 — 4000 = 1 kc/sec., and 4000 — 3999 = 1 kc/sec. The only other ones present are those at high radio frequencies and one of 4001 — 3999 = 2 kc/sec. The R.F. ones are filtered out, and the last, which is the second harmonic of the modulation frequency, is kept small in amplitude by proper design of the detector circuit. It can be seen, therefore, that the

original modulation is reproduced by each sideband beating with the carrier in the detector circuit, which is so designed as to pass on these beat frequencies and no others. Thus, is the signal has been deprived of its own carrier, it will not be possible to perform detection unless some means is provided at the receiver for supplying the lost carrier. This is what we should have to do, therefore, if we attempt to make use of double-sideband-suppressed-carrier transmission. We can generate a carrier in the receiver, and inject it, *a la* B.F.O., into the detector circuit along with the signal. Then, all will be well, and our modulation will be recovered. Or will it?

If the phase, as well as the frequency of the artificial carrier is correct, it will, but unfortunately, if the phase and frequency are not correct to within almost impossible limits, the modulation will be highly distorted, if at all recognisable. The reason for this is not far to seek. Remember, the detector produces two sets of audio frequencies, one from the beat between each sideband and the carrier. And if the phasing of the carrier is not what it should be, then the two quite separate audio outputs will not be in phase, and the relative amplitudes of the numerous audio components present will be so changed that the result is nothing like the original, even though all the correct frequencies are there.

S.S.S.C. TO THE RESCUE

So far we have been discussing the possibility of saving transmitter power by omitting to transmit the carrier once it has done its job of allowing the sidebands to be produced, but if doing so results in a signal that is virtually impossible to detect, we are not much farther ahead. The solution to the problem is to save even more transmitter power by cutting out the carrier and one sideband, leaving only a single sideband. This, too, can be detected onl by inserting at the detector an artificial carrier, but this time there is no other sideband to produce a second set of audio frequencies, and the phase of the carrier is of no consequence. Only its frequency must be accurately set, and with modern receivers this does not present any real difficulty.

At this, we seem to be getting somewhere. We have a system which, for a given amount of intelligence power delivered to the aerial, would require ony a sixth of the tube capacity in the final amplifier, compared with a conventional A.M. transmitter, in which two-thirds of the power output is unnecessary carrier, and half the remaining sideband power is redundant. To reduce this to figures once more, let us imagine a conventional transmitter which delivers a 100-watt carrier. Its power output at 100 per cent. modulation will be 150 watts, of which 100 is still carrier, with the remaining 50 equally divided between the identical sidebands. *To produce the same signal strength in the receiver, using S.S.S.C., we need only one sideband, with a peak power of* 25 *watts.* This could be provided by a final amplifier very much smaller than the one the conventional transmitter uses. Alternatively, the original final can be re-adjusted to give very much more effective sideband power than it ever did when it had to handle the carrier and the second sideband as well. As far as the final is concerned, the carrier is no more than excess baggage, to be carried!

OTHER ADVANTAGES

So far, only one possible advantage of S.S.S.C. operation has been touched on, but there are others, and much more far-reaching ones. First of all, it is necessary to point out that the generation of S.S.S.C. signals can, and does, take place at receiving-tube level. The audio power required is infinitesimal, so that no high-powered modulators are needed. As against this, the circuits are undoubtedly more complex in an S.S.S.C. transmitter, and need more careful adjustment, but one can do a good deal for the price of a high-power modulation transformer, not to mention the cost of the modulator's power supply!

After modulation and suppression of the carrier and the unwanted sideband have been accomplished, the power level of the signal can be increased only in Class A or Class B amplifier stages, because amplification must be linear, whatever the system used, after modulation has taken place. Up to an output level of 10 watts or so, Class A stages can be used, under exactly similar conditions to those under which the same tubes work when they are used as Class A audio amplifiers. For example, a pair of Philips EL37s, triode-connected, could give about 15 watts output, taking only voltage to drive them, no power being consumed in the grid circuit. This would produce a signal comparable to that from a conventional A.M. transmitter with a carrier power of 60 watts. Or, for an expenditure of approximately 113.5 ma. at 250 volts, as power supply for a single Philips EL37 as a Class A tetrode, a power output of 10.5 watts would be obtained, and would be equivalent in all respects, at the receiver, to a normal A.M. transmitter of 42 watts carrier power.

For higher power outputs, Class B stages can be used, but since they are handling R.F., and have tuned load circuits, they need not be push-pull. Indeed they are considerably easier to handle than the Class B linear stages that amateurs so sedulously avoid when dealing with ordinary A.M. transmissions.

All the advantages so far outlined make themselves felt immediately to the man who is going to do the actual transmitting, but what of the receiving end? Here too, S.S.S.C. shines, and it is not too much to say that *the widespread use of S.S.S.C. would enable the vast majority of present-day QRM to be avoided altogether.* Up till now, the only approach to the problem of ever-increasing heterodyne interference (due simply to vastly increased band occupancy) has been the quest for more and more receiver selectivity. Modern selectivity techniques have done a great deal to enable signals to be worked through QRM, but there is a definite limit to what can be done in this way. The best of all preventive measures would be to abolish the heterodynes at the source and this is one of the things offered by S.S.S.C. If carriers are not being transmitted, heterodyne whistles cannot occur. It is true, of course, that if someone else's single sideband is overlapping the transmission you are trying to copy, you will hear noises that can rightly be classed as interference, but the difference lies in the relative annoyance values of a loud, steady, tone, and a jumble of incoheretn noises, which in practice turn out to be much less distracting to the ear. When the interfering station stops modulating, the interference disappears altogether, but as everyone knows this is not the case if a normal A.M. transmission is causing a heterodyne.

Then again, each S.S.S.C. transmission on the air takes up only half as much space in the frequency spectrum as its A.M. counterpart, so that any given band will carry just twice as many channels as when A.M. is used.

As if these many advantages were not enough, there is an additional one which has been found to occur when S.S.S.C. is used for long-distance radio communications, such as radio telephone circuits. The Philips organization in Eindhoven has recently installed S.S.S.C. equip-

(Continued on Page 48.)

ARRIVING SOON!

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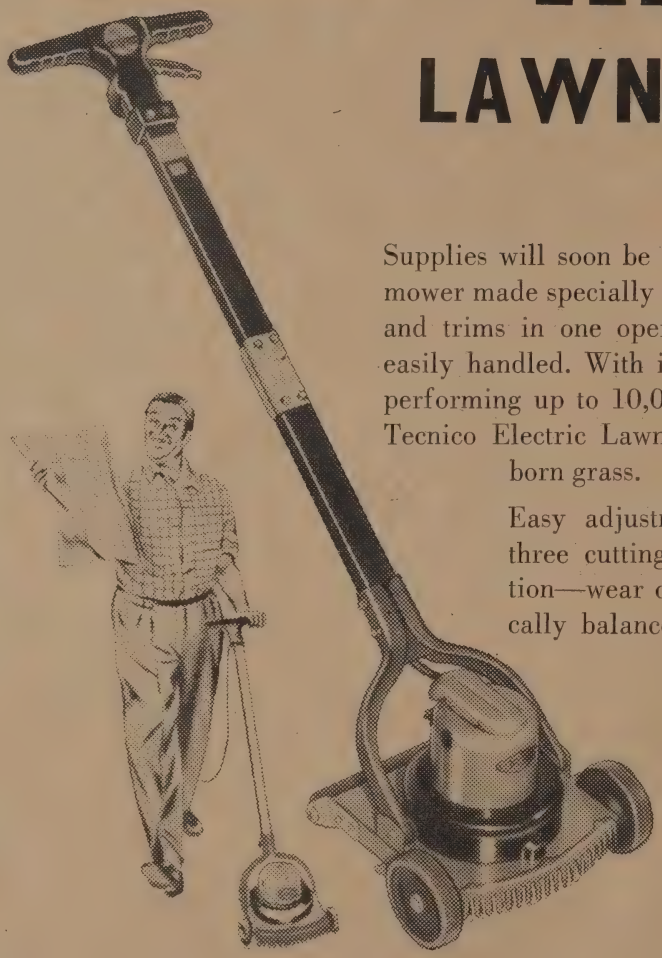

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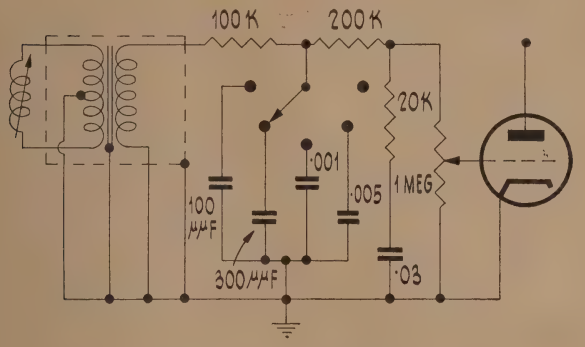
Pick-ups and Their Behaviour

(Continued from Page 23.)

stant velocity. In constant amplitude recording, the lateral movement (displacement) of the cutter is constant at all frequencies, for a given input voltage but the lineal velocity varies with frequency. In constant velocity cutting, the lineal velocity remains the same for a given input, whereas the amplitude changes.

It can be seen that a high amplitude low frequency signal cut with constant velocity would tend to force the cutter through the groove sidewall into the preceding groove, and further a high frequency signal cut with constant amplitude requires an extremely high lineal velocity, so that it is difficult to cut and impossible for a playback stylus to follow. This explains why frequencies below 300 c/sec. are cut with constant amplitude, to protect the sidewalls, but those above 300 c/sec. are cut at constant velocity, in commercial matrices.

Now a bimorph crystal pick-up is amplitude sensitive (see the curve hump at 300–500 cycles), whereas a magnetic pick-up is velocity sensitive, and so neither type is capable of producing a flat response characteristic from a commercial record.



Typical equalizer for a magnetic pick-up.

The equalizer comes into the picture here, to do the levelling out, but the process of equalizing results in a minimum loss equal to the largest departure from linearity in a positive sense, usually from 5 to 10 db., which is restored in the pre-amplifier—either before or after equalization.

CONSTANT VELOCITY AND CONSTANT AMPLITUDE

Magnetic pick-ups and cutters are constant velocity devices. This means that for a *given input voltage* to the coil, the amplitude of the wave cut on the disk at, say, 250 cycles will be twice as much as amplitude at 500 cycles and four times that at 1000 cycles.

Groove depth is about 0.0015 in. At 96 grooves per inch the centre-to-centre groove spacing is 0.0044 in., width is 0.006 in., and available wall thickness for modulation is less than

$$\frac{0.0044 \text{ in.}}{2}$$

(adjacent grooves share this).

Below the "cross-over" frequency (usually 300 cycles) the cutter is made to have constant amplitude, to deal with the heavy modulation, *e.g.*, at 96 g.p.i., and wall space 0.0044 in. maximum, permissible amplitude to either side is something less than 0.0022 in.

The reduction found necessary to keep the cutter from penetrating sidewalls of grooves at low frequencies is approximately 6 db. per octave from the "crossover" frequency downwards.

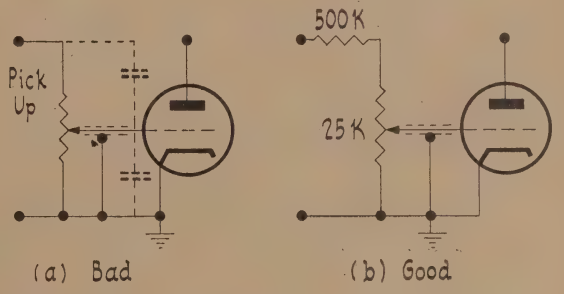
THE LOAD FOR THE PICK-UP

The load resistance is governed by the top resonant frequency of the L and R of the pick-up. Usually the better the pick-up, the higher in frequency is the top response of the armature and stylus. In practice a high-frequency pick-up will take from 0.5 megohms to 4 megohms. These remarks apply whether the pick-up feeds direct or through a transformer.

Now, while stylus and armature top resonance in a first-class pick-up is above audibility, many pick-ups suffer from top peaking in the region of 7 kc/sec., and this is just where scratch and surface noise is most troublesome. Two remedies exist: (a) heavy loading; (b) "trick" damping. Trick damping consists of surrounding the armature with a viscous substance, usually a grease, and finding the right amount by trial, plus the aid of a trap tuned to the peak frequency.

From a listener's angle, refinements and extended pick-up range mean little, if all amplifiers following the pick-up do not have absolute minimum overall distortion, certainly not more than 5 per cent.

Non-linearity means intermodulation, so that sounds are manufactured by the amplifier from two simultaneous fundamentals, bearing no harmonic relation to either, *e.g.*, 1000 cycles and 51 cycles; resultants 1000, 51, 102, 949, 1898, 204, etc., cycles. A very small amount of this



spurious energy is intolerable to the ear.

Minimum hum is an essential too; and lastly provision in the playback unit for bass and treble lift or cut to suit individual taste; this is due to the varying response of the ear to varying sound levels, plus the (usually) lower reproduction level as compared to original sound (Fletcher-Munson effect).

Now it is most important that the pick-up feeds into the right load impedance. The input impedance of the first valve is very high compared with the pick-up impedance, which therefore takes charge of the situation. A magnetic pick-ups internal impedance is predominantly L and R in series. To avoid random hum, shielding is necessary, but high value volume controls between pick-up and grid are a trap because of shield capacitance effects at the slider mid-point, causing "top" loss; it is better to use a high-value resistor feeding, say, a 25,000-ohm variable.

In B the low output resistance swamps the effect of the shielding. An interesting point in connection with special

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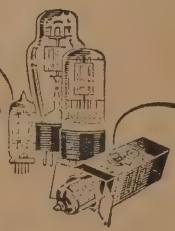

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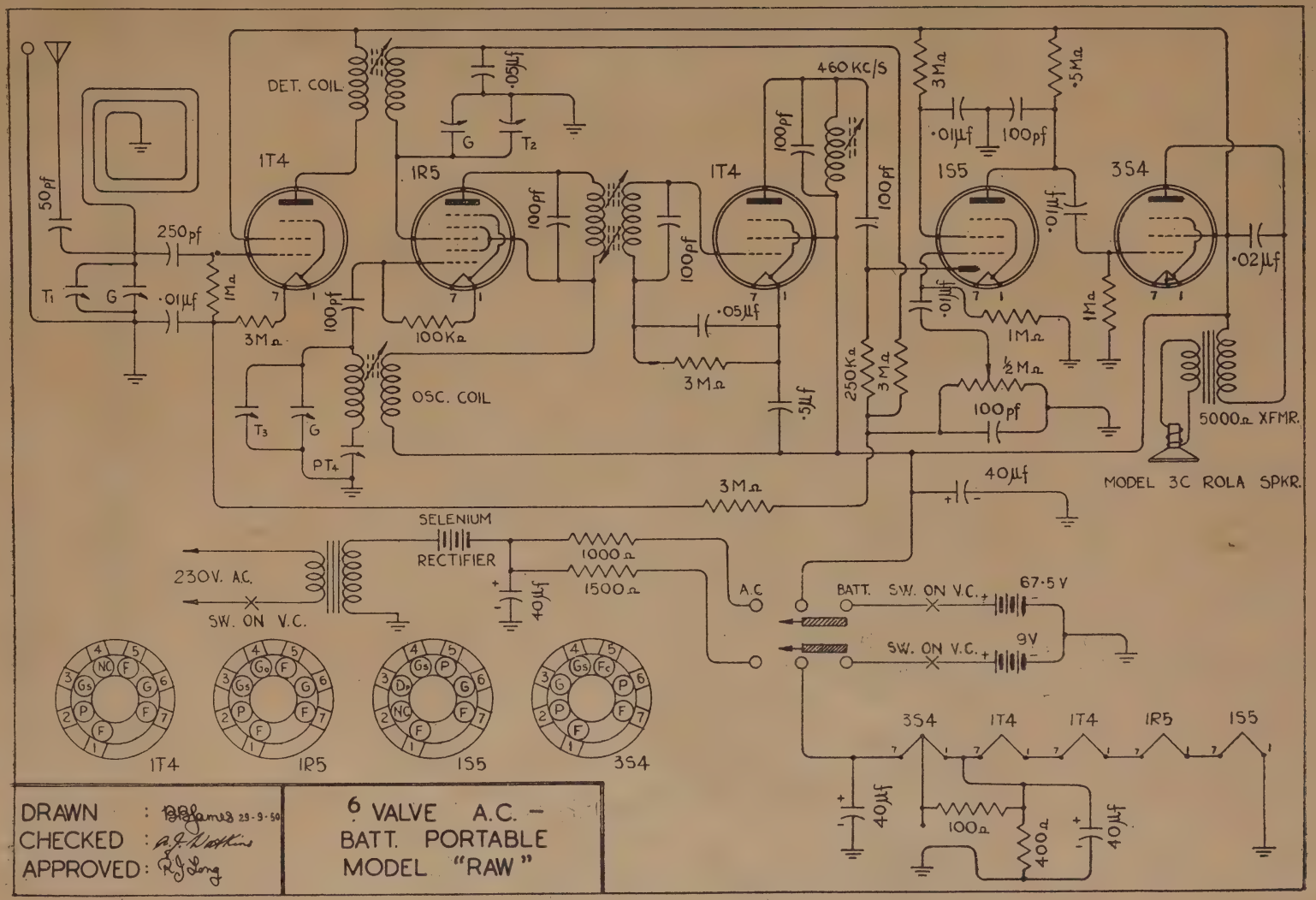

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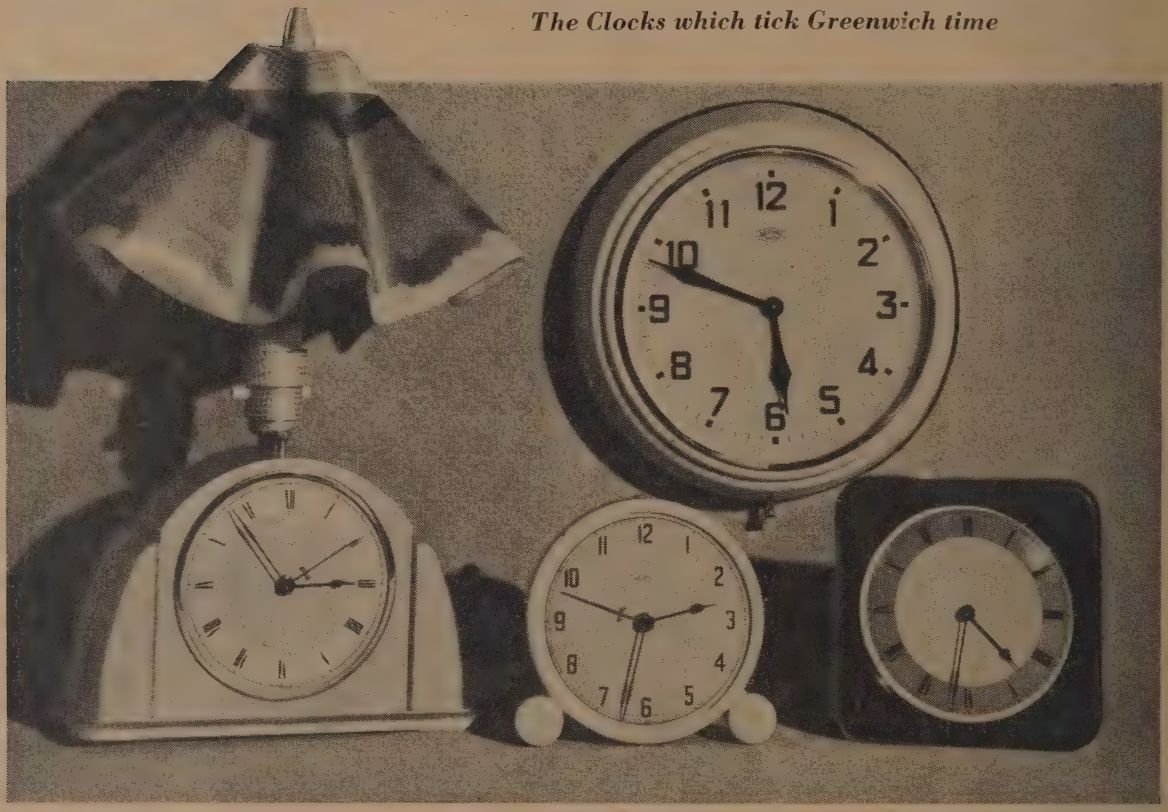

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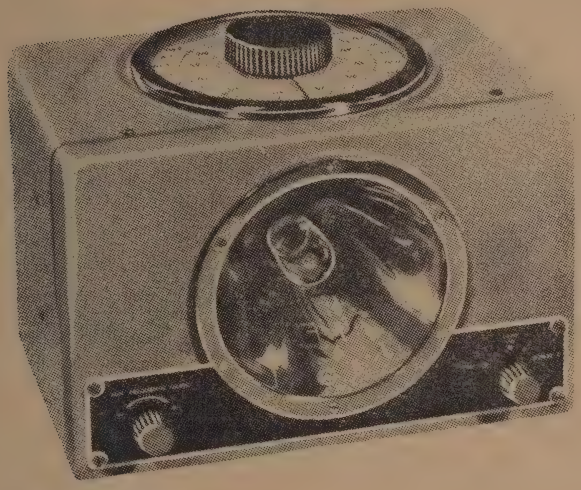


Application

This portable stroboscope serves for the visual examination of periodically moving parts of machinery, etc., while in operation. The flashing frequency of the neon lamp can be adjusted as desired and made equal to the kinetic frequency of the object being examined. With the apparently stationary picture thus obtained any mechanical deformations, displacements, etc., can be observed even when the object is moving at a high speed.

Owing to its small dimensions and low weight the instrument can easily be carried about and thus used examination of flywheels, driving gear, engines, pumps, for observations in places difficult to reach. It is an excellent instrument for determining speeds, and for the centrifuges, ventilators, printing presses, packing machines, propellers, electric fans, and movements of shuttles in weaving machines, etc.

Incorporated in the "Strobophil" underneath the neon tube is a metal spring which when switched in will vibrate at the 50-cycle mains frequency. By this means the accuracy of the flashing frequency indicated on the scale is made absolute.

TECHNICAL DATA

Frequency Range: 15–240 c/sec. (15-60 and 60-240 c/sec).

Accuracy of frequency: Absolute (provided the instrument is calibrated with the mains frequency).

Reading accuracy: Tolerance about 1 per cent.

Flashing time: About 5 microsec. for the lower frequencies; about 10 microsec. for the higher frequencies.

Frequency stability: With 10 per cent. mains voltage variation the frequency variation is at most 1 per cent.

Power consumption: About 35 watts (at 230 volts).

Dimensions: Width 11 in.; height, 8¼ in.; depth, 8 in.

Weight: 10 lb.

Finish: The apparatus is mounted in a light-grey damask enamelled steel case.

* * *

THE MASTER POCKET SET

Swan Electric Co. Ltd.., announce the Trimmer Kit, which no amateur or professional radio or television engineer can afford to be without.

The kit contains 1 End Trimmer; 1 Side Trimmer; 1 Yaxley Switch Contact Adjuster; 1 Low Capacity Trimmer; 1 Screwdriver; 1 Set of Feeler Gauges; 1 Set of six Box Spanners from 1 and 8 B.A.; 1 Set of four Spanners from 0 to 8 B.A.

In durable black crackle finish metal case, approximately four inches square by one inch deep. Retail price 57/6; normal trade discount.

* * *

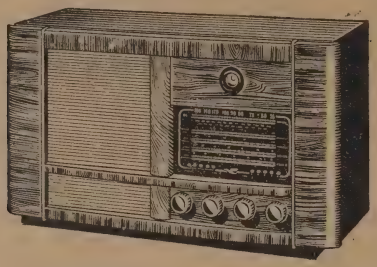
THE NEW ULTIMATE 7-VALVE BANDSPREAD MANTEL RECEIVER

The new Ultimate set illustrated here is housed in a distinctive cabinet which follows in design the latest continental trend that has proved extremely popular overseas and should present a pleasing change for the New Zealand public. Light, silky veneers give a pleasing contrast to the darker dial and control knobs and offsets the lighter grille cloth. Altogether it is a modern set of pleasing lines and quiet dignity.

A new range of valves which includes high slope pentode output tubes give increased selectivity and sensitivity.

New Products

(Continued from previous page)



The full vision dial with bandspreading on shortwave, is divided into five bands as under :—

Band 1—Broadcast 550 kc/sec. to 1600 kc/sec.
Band 2—41, 49, 80 metres.
Band 3—25, 31 metres.
Band 4—16, 19 metres.
Band 5.—13 metres.

Incorporated in the set is the new feature Pentonic Tone Control which gives five tone positions selectable by the operator.

General Specifications

Main : 230 volts A.C.
Wattage : 60 watts.
Cabinet : American walnut veneer.
Speaker : Rola 8H permanent magnet.
Retail price : £53 7s. 6d.

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Now Replaceable

with S.T.C. Miniature Radio Rectifiers

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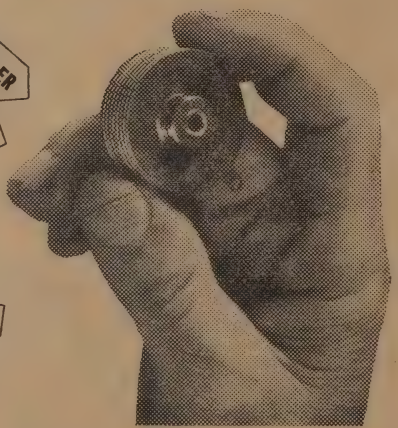
LASTS LONGER
RUNS COOLER
SAVES SPACE



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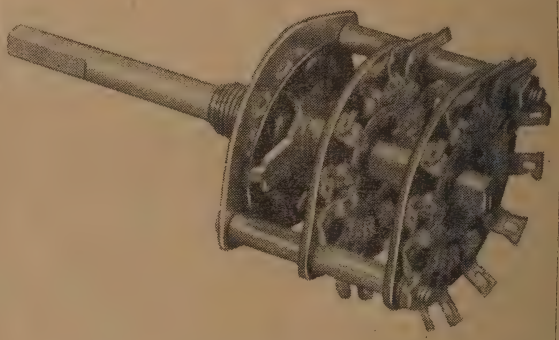

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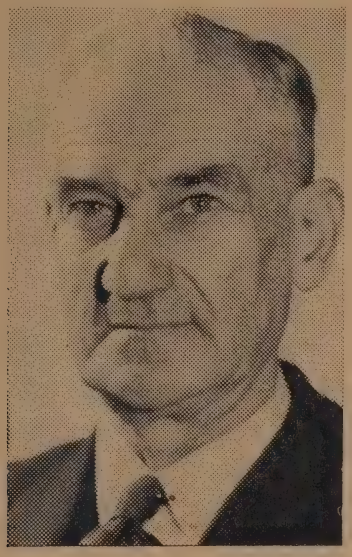
OBITUARY

Mr. Charles Joseph Lenihan, general manager of Turnbull and Jones, Ltd., died while attending a conference of the New Zealand Electrical Federation in Napier recently. He was 59.

A highly-respected executive, Mr. Lenihan was born in Victoria, Australia, in 1892, and came to New Zealand at the age of 12. He was with Gordon and Gotch from 1910 to 1911 before joining the British General Electric Company, Limited, when its office was in Willeston Street, Wellington.

During the First World War Mr. Lenihan served with the N.Z.E.F., going to Samoa shortly after the out-



—Evening Post Photo.

MR. C. J. LENIHAN

break of hostilities. He joined Turnbull and Jones in 1920, was appointed manager of the firm's Wellington branch in 1927, and to the Auckland managership in 1934. He returned to Wellington in April, 1946, after being appointed the company's general manager.

Mr. Lenihan was largely responsible for the formation of the New Zealand Cable Makers' Association in 1924, and was its president for a number of years. He was a former president of the New Zealand Electircal Federation (Inc.), and was at one time executive member of the Wellington Wholesalers' Electrical Traders' Association.

He is survived by his wife, a son, and a daughter.

The funeral took place at Karori following a service at St. Patrick's Church, Kilbirnie. The pall-bearers were Messrs. J. Lee, vice-president of the New Zealand Electrical Federation; C. L. Dentice, president of the federation; R. Allum, of Allum Electrical Co., Ltd., and chairman of the New Zealand Cable Makers' Association; W. Kerr, of Philips Electrical Industries (N.Z.), Ltd.; C. L. T. Williams, and E. Harrison, both of Turnbull and Jones, Ltd.

NZ RADIO TRADERS FEDERATION MEMBER

The Badge that will protect you and add prestige to your business.

This Federation is a live body working on behalf of Radio Traders' interests throughout New Zealand.

Let your voice be heard in discussions of trade affairs vital to your business. The Federation wants your views, too.

The Federation consists of the following Associations, and you are invited to make contact with your nearest.

AUCKLAND PROVINCIAL RADIO TRADERS' ASSOCIATION. Secretary: J. E. Beachen, P.O. Box 611, Auckland.

CANTERBURY RADIO TRADERS' ASSOCIATION. Secretary: H. F. Butland, P.O. Box 359, Christchurch.

HAWKE'S BAY RADIO TRADERS' ASSOCIATION. Secretary: G. H. Rees, P.O. Box 435, Hastings.

MANAWATU-WAIRARAPA RADIO TRADERS' ASSOCIATION. Secretary: S. I. McKenzie, P.O. Box 405, Palmerston North.

NAPIER AND DISTRICT RADIO TRADERS' ASSOCIATION. Secretary: J. Fairclough, P.O. Box 12, Napier.

NELSON RADIO TRADERS' ASSOCIATION. Secretary: A. A. Johnson, P.O. Box 20, Nelson.

OTAGO RADIO TRADERS' ASSOCIATION. Secretary: F. W. McCullough, P.O. Box 740, Dunedin.

POVERTY BAY AND EAST COAST RADIO TRADERS' ASSOCIATION. Secretary: Selwyn Gane, 309 Gladstone Road, Gisborne.

SOUTHLAND RADIO TRADERS' ASSOCIATION. Secretary: A. S. Alsweiler, P.O. Box 311, Invercargill.

TARANAKI RADIO TRADERS' ASSOCIATION. Secretary: J. N. Laird, P.O. Box 283, Hawera.

WANGANUI RADIO TRADERS' ASSOCIATION. Secretary: V. T. Bennett, P.O. Box 307, Wanganui.

WELLINGTON RADIO TRADERS' ASSOCIATION. Secretary: C. G. Camp, P.O. Box 796, Wellington.

This announcement is inserted by the New Zealand Radio Traders' Federation, Headquarters, 8-12 The Terrace, Wellington.

Letter to the Editor

The "R. & E." 1951 V.H.F. Programme

Sir,—You are to be congratulated on your enterprise in undertaking "The 'R. & E.' 1951 V.H.F. Programme." I have been interested in, and active on, the V.H.F. spectrum of amateur frequencies for some years now, and have watched the steadily growing interest taken in V.H.F. Your proposal gives me great encouragement.

There is one point in V.H.F. work worthy of note. Much of the severe QRM experienced on 80 metres could be avoided. All local and short haul work could and should be done on the V.H.F. bands, including 420 mc/sec., to avoid causing 80-metre QRM. Much 80-metre cross-town work causes QRM to the whole of New Zealand, whereas if cross-town work was done on a V.H.F. band probably no QRM would be caused.

Your programme of practical constructional articles will be of great assistance in getting interested amateurs started on the V.H.F. bands.

In this district there already is considerable V.H.F. activity. My log shows many whole pages of 144 mc/sec. contacts, including Dunedin and Wellington. On 420 mc/sec. we have had many 25-mile two-way contacts with excellent signals. We have worked 50 miles on 420 mc/sec.

My transmitters are crystal or V.F.O. controlled on 50 and 144 mc/sec. On the 420 mc/sec. I have two transmitters. One is self-excited, using a pair of 316A "door-knob" tubes. The other is crystal or V.F.O. controlled, using an 832 tripler-amplifier as final tube.

Receivers for six metres are a BC624AM as complete receiver, or a cascade low noise converter ahead of a communications receiver. For two metres, a modified BC624C is used as a separate receiver. Tube line-up is 6AK5 R.F., 6AK5 mixer, 9002 oscillator, 9003 oscillator isolator, three stages of 125G7 I.F. on 12 mc/sec., 12C8 detector and A.V.C. and first audio, 12A6 output, 12H6 noise limiter, 12AH7 B.F.O. A superhet is used on 420 mc/sec. Tube line-up is 955 mixer, 955 oscillator, three stages 6AC7 I.F. on 30 mc/sec., 6H6 detector, 6J5 first audio and 6V6 output.

In conclusion I wish you well in your "'R. & E.' 1951 V.H.F. Programme."—Yours etc.,

V. P. LOVETT, ZL3AQ.

* * *

PUBLICATIONS RECEIVED

The ABCs of Radio, prepared by Electronics Department G.E. Co. (U.S.A.) (National Elec. and Eng. Co., Ltd.).

Special Products Digest, G.E. Co. (U.S.A.) (Nat. Elec. and Eng. Co., Ltd.)

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Stock Record, August, 1951. Cory-Wright and Salmon, Ltd.

Westinghouse Engineer, July 1951. H. W. Clarke (N.Z.), Ltd.

"Television Explained," by W. E. Miller, M.A. (Cantab.), M.Brit.I.R.E.. Fourth Edition. Published at 5s. net (postage extra), by Trader Publishing Co., Ltd., and distributed by Iliffe and Sons, Ltd. Size 8¾ x 5½, 104 pages, including 59 diagrams and 16 photographs.

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LABOUR DAY WEEKEND TRAVEL

Some Additional Trains Will Run

Because of the continued shortage of coal supplies, the Railways Depratment is compelled to restrict the number of trains which can be provided for Labour Day weekend travellers.

The present curtailed express and passenger train services will, however, be supplemented by a limited number of additional trains leaving the main centres on Friday evening, 19th October, returning on the Monday afternoon or evening.

Bookings for trains leaving on Friday, 19th October, open on Friday, 5th October.

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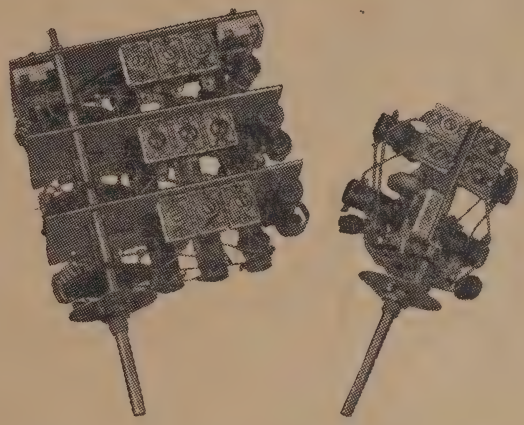

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TYPE 24A D.W. SINGLE PRE-SELECTOR STAGE, 540 to 1600 kc/s., 6 to 20 mc/s.— **£3/13/11**

TYPE 34A D.W. WITH R.F. STAGE, 540 to 1600 kc/s., 6 to 20 mc/s.— **£6/2/8**

TYPE 64A T.W. WITH R.F. STAGE, 540 kc/s. to 20 mc/s. in three bands— **£6/13/9**

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157 THORNDON QUAY - - WELLINGTON

New Type Gas Discharge Tubes for Use in Electronic Counting Circuits

Two new cold cathode glow discharge tubes have been developed by Standard Telephones and Cables, Limited, for general counting use: the G10/240E unidirectional ten-point "Nomotron" and the G1/370K high-speed trigger tube. While both mark a big advance in cold cathode tube technique, the G10/240E is, perhaps, the more interesting in that it embodies an entirely new approach to the problem of circuit simplification and higher speeds in the gas tube art.

The G10/240E "Nomotron" enables up to ten pulses to be counted and the results stored in a single tube by means of a glow discharge which advances in steps according to the number of impulses received. Only a single pair of input terminals is required, one of these normally being earthed, unidirectional transfer of the discharge from step to step being accomplished by means of the electrode geometry. The tube has been developed to use an anode supply of 300-350 volts, and operates at all pulse repetition speeds from zero (random pulses) to rates in excess of 25,000 pulses per second.

The tube has ten storage cathodes from any one of which an output pulse may be obtained. The storage cathodes co-operate with a common anode and ten internally connected transfer cathodes to which the pulses to be counted are applied. The storage and transfer cathodes are arranged alternatively to form a circular array of glow discharge gaps with the common anode. The storage cathodes are asymmetrically shaped, and each is so formed that a stable glow discharge may be maintained immediately adjacent the transfer cathode next in the sequence of discharge rotation around the tube.

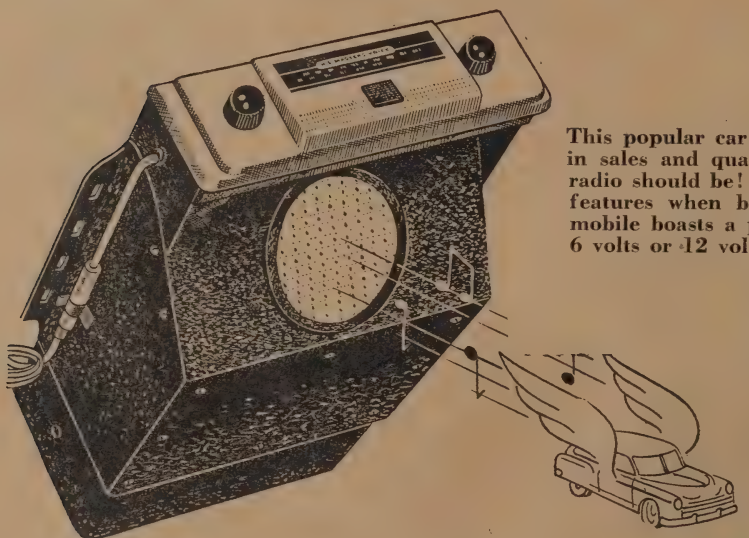
Assuming a glow discharge at one of the storage cathodes, the application of a negative pulse to the common transfer cathode terminal causes the transfer gap next to the existing discharge to fire and to extinguish the discharge on the storage cathode. When the pulse is removed, the discharge at the transfer cathode is transferred to the next storage cathode, where it is maintained until the arrival of another pulse. By this means, at each successive pulse the glow discharge is transferred forward one position, discharge being maintained at only one gap at a time.

The G1/370K trigger tube has been developed as a general purpose, high-speed, high input impedance cold cathode trigger tube especially suitable as a driver for the G10/240E "Nomotron." This tube includes a priming gap across which a very small auxiliary discharge is permanently maintained to overcome "statistical" delay of firing of the trigger gap. The main electrode structure comprises an enclosed main gap which is effectively shielded from external sources of ionization and from the auxiliary priming discharge so that its firing is completely controlled by the trigger discharge. The trigger gap is so arranged with respect to the main gap that there is no measurable time lag in transfer of discharge from trigger to main gap. Deionization is extremely rapid, and,

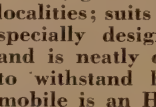
The reasons why the

Radiomobile

is miles ahead!



This popular car radio—the Radiomobile—is miles ahead in sales and quality because it really is everything a car radio should be! . . . Your customers look for special features when buying a car radio, and H.M.V.'s Radiomobile boasts a power pack alongside; operates on either 6 volts or 12 volts D.C.; gives remarkable reception in all localities; suits any make of car, although specially designed for English models, and is neatly compact yet sturdily built to withstand heavy travel. The Radiomobile is an H.M.V. product, so it must be outstanding!



H·M·V

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due to the rigid shield construction, together with the auxiliary priming discharge gap, the characteristics are extremely stable and reproducible from tube to tube.

The G1/370K trigger tube is designed to operate from the same anode supply as the G10/240E "Nomotron," namely 300–350 volts D.C., and does not vary in performance whether dealing with entirely random pulses or with a succession of pulses up to a repetition rate in excess of 100,000 pulses per second.

These two tubes provide the circuit designer with a pair of circuit elements which enable revolutionary advances to be made in counting and similar pulse circuits without loss of efficiency, at working speeds considerably in excess of anything previously possible with gas discharge tubes.

* * *

BRITISH RADIO AND TV FOR THE WORLD

Radio, television, and electronic equipment, which British manufacturers have done so much to invent and develop and are now exporting to the value of nearly £18,000,000 a year, is reviewed in a booklet published by the Radio Industry Council (Great Britain) for circulation overseas in connection with the National Radio Show at Earls Court, London, from August 28 to September 8, 1951.

Twenty-five different aspects of the industry are touched upon, ten chapters being devoted to television development in Great Britain and the remainder to radio and sound reproduction, communications and navigational aids, electronics in industry, science and medicine, valves and cathode ray tubes and components and accessories.

The Story of a Golden Jubilee

On the 5th January, 1901, H.M.S. *Ophir* arrived in Melbourne bringing the Duke and Duchess of Cornwall and York (later to become King George V and Queen Mary) for the opening of the first Australian Federal Parliament. Six separate States were united to become a nation. This was the foundation of the Commonwealth of Australia.

There was also the foundation of one new concern in Rowe Street, Sydney, in February of that year which did not detract any attention from the Royal celebrations. Just 50 years ago, almost to the day, a Mr. Harry Veen, with the assistance of his wife and one operator, opened the first factory to manufacture dry batteries in Australia. The batteries carried the name of "Eveready." If little notice was taken of Mr. Veen's venture it was not surprising. This was still the gaslight age. Electric flashlights were a novelty; radio sets, which later were going to use hundreds of thousands of batteries every year, had never been heard of.

Fifty years have passed. The first factory has long since gone and during this period "Eveready" has grown up side by side with the Commonwealth—expanding, building, and constantly improving until today in Sydney the factory with 100,000 feet of space, represents the largest and most modern dry battery manufacturing plant in the Southern Hemisphere.

The New Zealand trade will remember that early in 1936 the "Eveready" organization commenced activities in New Zealand when a Sales Office was opened in Wellington by the late Mr. A. K. (Jacko) Jackson, and in 1938 took over the old Vulcan factory in Christchurch where batteries were produced until late 1939 when the Company commenced manufacturing in the present Wellington plant.

From a very small beginning the New Zealand factory also has grown to a compact efficient organization with 175 employees and is proud to be associated with the Australian company on the occasion of its 1951 golden jubilee.

* * *

ROYAL VISIT

Contract by Green and Cooper for Pye Equipment

We are advised that the Police Department has just placed an order for Pye V.H.F. equipment to be used in Royal tour cars during the forthcoming visit of His Majesty and party. The equipment consists of three type P.T.C. 703, base stations and ten type P.T.C. 114, mobile units. The P.T.C. 114 is also fitted with special muting circuit, the power output of the transmitter being 15 watts. This model has also been ordered by the London Metropolitan Police who up till recently have been using F.M. equipment. Other equipment which will be used is a Pye walkie-talkie unit on V.H.F., the dimensions being practically the same as model 7 AVO meter.

THE 1951 "R. & E." DIGEST OF CIRCUITS

A feast for the constructor. Contains a large selection of circuits which have appeared in "R. & E." over a period of approximately two years. Price 3s. 6d. Available from booksellers and radio stores or direct from Radio and Electronics.

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TRADE WINDS

Auckland Provincial Radio Traders' Association

The annual meeting held in August was almost a record for lengthy discussions. Commencing at 7.30 p.m., it extended to 11 p.m. Mr. H. J. Barr was in the chair. A cordial welcome was extended to the President of the Federation, Mr. J. Fairclough, who had come specially from Napier for the meeting. The annual report covered a wide range of subjects dealt with during the year, and showed that revived interest in traders' problems was taking place by the fact that nineteen new firms or dealers had joined the Association, the present membership being 133. The feeling that the annual meeting of the Federation, held at the Chateau was the best yet was expressed in the report, not only from a social viewpoint but from the business angle as well. It enabled members fully to appreciate the large amount of work done by the Federation and it showed that very cordial relations existed between the Federation and Provincial Associations. In reviewing past work the report expressed the value of all members using the new membership badge, and observing the list of bona fide dealers. The report stated in no uncertain terms the dissatisfaction about the import control position and of the handling of certain sections by the Federation.

In November, the executive and secretary travelled to Hamilton to meet the Waikato dealers, spending an interesting evening, all reaping the benefit of an exchange of views between city and country dealers.

Although socially the Traders' Ball, held last year, was a success, the attendance was disappointing and resulted in a financial loss.

After formal business was disposed of, and election of officers completed (see *Radio and Electronics,* September issue), Mr. S. Christie, the new President took the chair, and asked Mr. Fairclough to address the meeting.

In his usual interesting and informative manner the Federation President touched on the wide variety of subjects dealt with by the Federation and stated that although those not so close to the executive might think the activities were slow, he wanted it clearly understood that this was not done with any sense of frustration. There were certain inherent difficulties in getting the executive together, but in the main, delay arose through following the proper channels of communication to reach the desired person in the Government departments and to obtain from these officials some adequate action. However, said Mr. Fairclough, it was necessary for the Federation to investigate the requests of all Associations as the Federation must act uniformly in the interests of the whole of New Zealand. He pointed out that the Federation had agreed to utilize the services of *Radio and Electronics* magazine as the official organ, and the Editor had undertaken to give the utmost possible publicity to the doings of the Federation and Provincial Associations and would welcome any information of interest to traders generally. Mr. Fairclough stressed the value of the Federation Seal, recommending to members the use of this as it added prestige to those using it. Although the trade-in booklet was open to correction, it would be printed in its present form, and in the reprint changes would be made in accordance with the wishes of members. Regarding control of imports and the action of the Federation in the various matters involved, Mr. Fairclough explained some of the difficulties over the negotiations re condensers, and he was asked at this juncture to include the list of Auckland firms to Ducon (N.Z.) Ltd. The Federation was pressing for the right to import the market requirements of speakers over and above the estimated manufacture, if not for complete release. Regarding batteries, release was being pressed for.

Television was dealt with briefly and some discussion took place on the advisability of setting up training schools for technicians. The Federation was in touch with certain manufacturers who were investigating this very situation. It was suggested to Mr. Fairclough that it might now be advisable for the Federation to include in its name some reference to television and electronics.

At the conclusion of his address, Mr. Fairclough was accorded a very hearty vote of thanks.

Other matters dealt with by the Association were that of mark-up of radios, guarantees, price cutting, etc., and these were left for the incoming committee to make recommendations.

Mr. J. Barr, retiring President, was accorded a vote of thanks for his work over the past twelve months and appreciation was expressed for the co-operation and services rendered by the Secretary, Mr. J. E. Beachen.

"PHILCO" Leadership Club World-wide

This emblem, which is now to be seen on the Sales Staff of numerous Radio Dealers throughout the countryside, indicates membership of "Philco World-wide Leadership Club."

As inquiries have been made as to what this Club is and what it is all about, for the information of readers, this is a movement fostered by Philco International Corpn., of America, to link all "PHILCO" Radio Sales personnel throughout the world. "PHILCO" prides itself that beside being America's leading Radio seller it has ramifications at all points of the globe.

Besides providing a common bond for "Philco" selling personnel, this club will also be the media of distributing to members, information on "Philco's" activities throughout the world. Among other things, they will regularly receive copies of the "PHILCO WORLD," a publication which deals with the activities of "Philco."

Knowing one another and knowing what is going on in various territories should lead to co-operation and exchange of ideas which should be invaluable to members, apart from which the wearing of the lapel emblem indicates to others the fact that the wearer is a member of the Club and has interests in common with others in the Club.

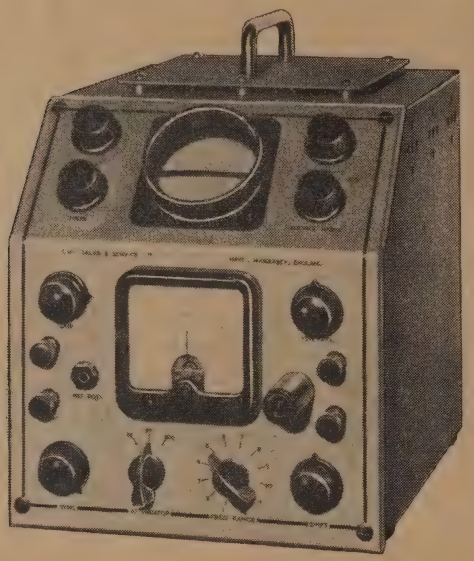
Published by Russell Import Co., Ltd., Wellington, Sole New Zealand Distributors for Philco Products

The Editor's Opinion

The E.M.I. Cathode Ray Oscilloscope

The oscilloscope is recognized as one of the most powerful tools at our disposal, for the investigation of the behaviour of electronic circuits, so that it is not at all surprising to find that many of the more progressive service workshops are provided with one as a matter of course, when only a few years ago an oscilloscope was considered an expensive luxury.

One thing, however, still prevents many who would like one from investing in a 'scope, and that is the expense. Existing commercial instruments are mostly designed with a view to the requirements of the research laboratory



rather than those of the radio serviceman, and their price is correspondingly higher than the average serviceman can afford to pay. At the other end of the scale, there are on the market in some parts of the world (but not in this country) oscilloscopes whose specification is such as to make them hardly suitable even for the simplest audio work.

The E.M.I. oscilloscope, however, comes into neither of these categories. Its construction is excellent, and its design shows a keen appreciation of the essential features of the oscilloscope in so far as the user is concerned. Effectiveness, combined with simplicity, may be said to be the outstanding attributes, but for good measure, as it were, the makers have incorporated one feature which increases the usefulness of the 'scope several-fold, but which is rarely found in any but the most expensive laboratory-type instruments. We shall have more to say about this later.

GENERAL DESCRIPTION

The general appearance is well illustrated in the photograph, but this does not bring out one important feature —namely, the conveniently small depth of the case. This is brought about by the use of one of the modern short 3 in. cathode ray tubes, which is mounted at an angle, further reducing the space needed in the front-to-back direction. All controls are conveniently placed, with the exception of some of the seldom used ones, and those which can legitimately be regarded as pre-sets, and these are to be found on a panel at the back of the case, readily accessible when needed.

The circuit, apart from the C.R. tube itself, and the two rectifier valves, employs only four valves. Two of these, KT81 tetrodes, comprise a long-tailed pair phase-inverting amplifier which provides balanced deflection voltages for the Y plates, from the usual single-ended input. The input grid of this stage is fed from a three-step attenuator giving ratios of 1 : 1, 10 : 1, and 100 : 1. The attenuator is capacitatively compensated so that the response curve of the amplifier will remain reasonably constant over the working range of the continuous gain control. The latter is provided by a rheostat bridging the cathodes of the KT81s. Its control range is slightly in excess of 10 : 1, which, in conjunction with the stepped input attenuator, gives continuous control from full input to one thousandth of the applied signal voltage. This arrangement cannot reduce the signal to zero, but this is quite unimportant compared with its specific advantage, which is to ensure that the response of the whole amplifying system remains constant, irrespective of the setting of the gain controls.

The response of the Y amplifier extends to over 2 mc/sec., so that excellent performance is obtained when the 'scope is being used for the examination of square-waves, pulses, and other signals containing frequency components well into the video range. The frequency for 3 db. drop in the response is 800 kc/sec., while that for 6 db. down is 1.2 mc/sec.

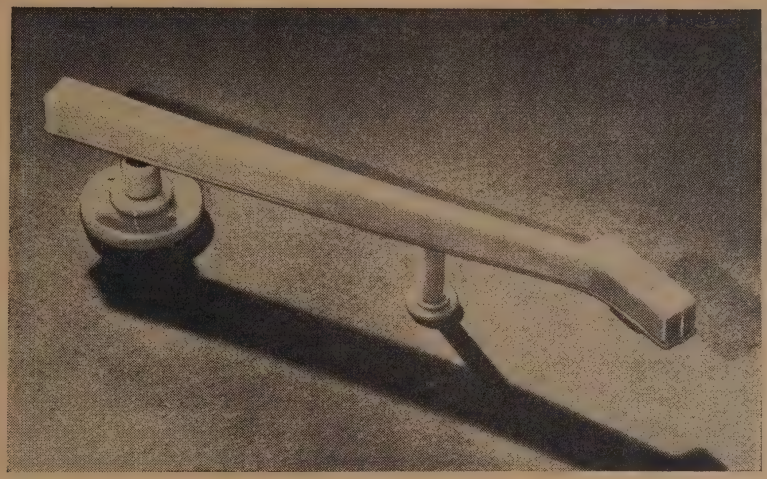
The internal time-base is a transitron saw-tooth oscillator, employing a Z66 pentode. The frequency range is from 3 c/sec. to 120 kc/sec., in twelve ranges, and there is generous overlap between adjacent ranges. This makes the 'scope very easy to use, especially with the easy synchronization that is characteristic of the transitron circuit. The time-base voltage is fed first to a phase inverter, consisting of an L63 triode with equal load resistors in plate and cathode circuits, so that balanced deflection voltages are provided for the X plates.

A SPECIAL MEASURING CIRCUIT

An unusual, but exceedingly useful feature of this oscilloscope is the arrangement provided in order that direct measurements may be made of the voltage of the whole, or any part of the waveform being displayed on the screen. This facility immeasurably increases the usefulness of the instrument, since it converts it into an actual measuring instrument, so that it fulfils all the functions of a vacuum-tube voltmeter in addition to its normal one of displaying wave shapes. The circuit which brings all this about is very simple and ingenious, making use of the fact that the Y amplifier tubes are directly coupled to the deflection plates, and of the peculiarities of the long-tailed pair amplifier circuit. In this circuit, input is applied to one grid, while the other is earthed to signal voltages through a large capacity. The second valve obtains its signal excitation by virtue of the cathode follower action of the first valve, but it is quite possible to make the circuit function by feeding a signal to either grid, since the arrangement is symmetrical. In this case, a variable D.C. bias voltage is fed to the grid which is earthed for signal voltages, and this direct voltage is

(Continued on Page 46.)

"RONETTE" *Miniweight Pick-ups*



PICK-UPS AVAILABLE COMPLETE WITH CARTRIDGES

Type MW2 Is supplied with a standard cartridge NL50-2 for use on both long-playing records and on normal 78 records. The frequency response extends to 5,000 cycles.

Type MW3 N or L; is supplied with a cartridge Type N50-3 for use on 78 records and with a frequency response up to 7,500 cycles.

For long-playing records cartridge Type N50-3 must be changed for cartridge L50-3.

Type MW4 N or L; with cartridge Type N50-4 for use only on 78 records with a frequency response up to 14,000 cycles. For long-playing records cartridge N50-4 must be changed for cartrige Type L50-4. This pick-up is mainly for professional users.

DESCRIPTION OF CARTRIDGES

The general designation of the crystal cartridge with sapphire stylus is NL 50. The sapphire stylus is indicated as N for normal or standard disks and L for slow-speed disks.

The Ronette Model NL50-2 is used for both standard and slow speed disks. Rapid replacement of the cartridge is made possible by its simple method of fixing.

Model NL 50/2/N is an extra light pick-up cartridge with a response up to 5000 cps. and standard size sapphire.

Model NL 50/4/L is an extra light pick-up cartridge with response up to 14,000 cps. and sapphire stylus to suit long-playing records.

TECHNICAL DETAILS

Type	*Output*	*Weight*	*Construction*
Model NL 50/2/N	0.8 volt mean	6.5 grammes	In plastic with silver-plated contacts.
Model NL 50/2/L	0.4 volt mean		

SAPPHIRE NEEDLE

Model NL 50/-/N	.00295 in.	± .0004 in.
Model NL 50/-/L	.00098 in.	± .00013 in.

Measurement with a sweep frequency disk shows negligible distortion. By using the minimum weight of the cartridge a needle pressure of 6 grammes is enough for the whole arm and wear on the disk is almost nil.

"RONETTE" MINIWEIGHT PICK-UPS are made at the laboratories of N. V. RONETTE, Piezo Electric Industry, Amsterdam, Holland.

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Book Reviews

Television Explained, by W. E. Miller, M.A. (Cantab.), M.Brit.I.R.E., Fourth Edition; published by Iliffe and Sons, Ltd.; 104 pages, including 59 diagrams and 16 photographs.

In these days, everyone concerned in any way with radio technicalities, whether as professional engineer, dealer or serviceman, as student, as amateur experimenter, or simply as a technically-minded member of the public, must be equally *au fait* with the workings of television receivers. This well-known book, now in its fourth edition, meets the needs of all who want such information presented in a straightforward, easy-to-follow manner.

The book is addressed to those members of the public who already have some knowledge of radio circuits and are interested in their television counterparts; to radio servicemen as a grounding in the circuitry they will encounter when working on TV receivers; and to radio and television students at technical colleges.

It is non-mathematical, is written in simple language, and is comprehensively illustrated. A valuable feature is the series of actual photographs of picture faults, with a note of the appropriate remedy to be applied in each case.

There is a special chapter on receiver installation and maintenance, and the author also gives the latest available information on the TV frequencies to be used by the B.B.C. when all the new transmitters are in operation.

Contents include: Photographs of possible picture faults in picture reception; aerials; the signal; the receiver outlined; the receiver in detail; sync separation; the cathode-ray tube; scanning circuits; deflection amplifiers; power supplies; receiver installation and operation; appendix I and II; index.

Radio Valve Data: Characteristics of 2,000 Valves and Cathode-ray Tubes; published by Wireless World, London.

The new edition of this well-known reference book of 80 pages contains the main characteristics of over 2,000 types of British and American radio valves, and over 100 cathode-ray tubes. Eighteen British valve manufacturers alone are represented, all of whom have co-operated with *Wireless World* in ensuring that the tabulated information given is accurate, comprehensive and up-to-date.

The main tables give the electrical characteristics of each valve, and separate tables show their base connections. Sub-divisions of the main tables further classify the valves into obsolete, replacement, or current types as recommended by the makers. An index enables any valve to be found in the tables quickly and without trouble.

The following classes of valves are shown: frequency-changers, screened tetrodes and pentodes, output valves, diodes, output valves and efficiency diodes for television line scan circuit, amplifier triodes, transmitting valves of various types up to 50 watts anode dissipation, valve rectifiers, E.H.T. rectifiers, tuning indicators, barretters, voltage stabilizers and thyratrons. In addition, non-thermionic diodes of the silicon, germanium, and selenium types are listed, and also metal rectifiers. The cathode-ray tube section covers all British tubes for television receivers and oscilloscopes.

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6-Metre Receiver

(Continued from Page 11.)

tralization is to set the two neutralizing condensers so that their plates are exactly one-sixteenth of an inch apart. This done, a signal is applied at 52 mc/sec., and is tuned in on the set with the main dial. The two series-connected trimmers across the input circuit are then tweaked for maximum output, thus bringing the first tuned circuit into line with the rest of the set. At this stage we do not worry about tracking the first circuit. When resonating the first circuit, care must be taken to see that the two condensers are set at exactly corresponding positions. In this way, the circuit is balanced quite accurately and equal signals are applied to the push-pull grids of the R.F. tube. A single-turn loop coupled to the R.F. coil will suffice for injecting signal from a signal generator, or noise from an aerial.

When this has been done, the two neutralizing condensers are adjusted very carefully, until an absolute minimum is found in the output of the set. It is surprising how slight the final adjustments must be, and how large an effect they have on the very small residual signal that gets through. While the neutralizing condensers are being adjusted, nothing else should be touched, except the main tuning dial, which should be kept tuned right "on the nose" by repeated adjustments for MAXIMUM output. When minimum signal output has been found by adjustment of the neutralizing condensers, have a look at them, and see whether their capacities are still obviously very similar. If a noticeable difference in setting is apparent, something is wrong, and it is probably that the input circuit is not properly balanced. This can be remedied by making a slight alteration to the balance of the trimmers in the grid circuit, while still re-tuning them for resonance, and then re-adjusting the neutralizing condensers for minimum output.

(To be continued.)

R.N.Z.A.F. Automatic Morse Transmissions

In response to a large number of requests from both civilian and service personnel for additional evening transmissions it has been decided to discontinue the morning transmissions, at present broadcast between 0800 and 0900 hours daily.

As from Monday, 8th October, M.C.W. transmissions will be made daily as follows:—

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1845–1900 hours	(b)	10 w.p.m.	
1900–1915 hours	(c)	15 w.p.m.	
1915–1930 hours	(d)	20 w.p.m.	
1930–1945 hours	(e)	25 w.p.m.	
1945–2000 hours	(f)	30 w.p.m.	

On week-day (Monday–Friday) transmissions (a), (b) and (e) will be rebroadcast commencing at 2000 hours.

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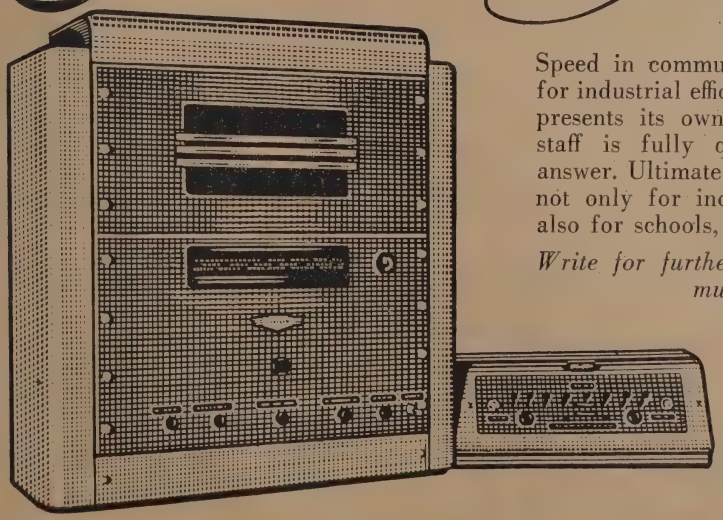

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The Editor's Opinion

(Continued from Page 42.)

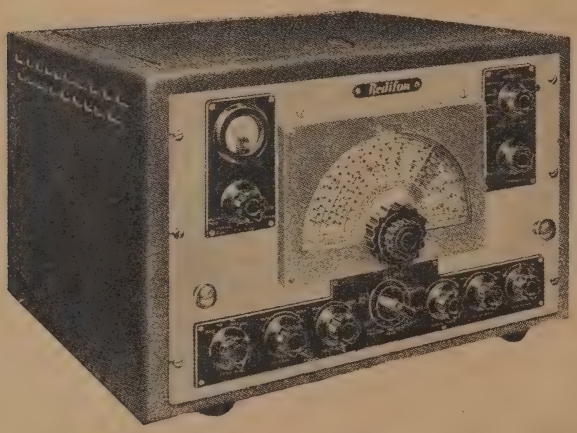
amplified and comes out at the plates as a balanced-pair of D.C. voltages which act as the vertical shift. Because of the amplification in the circuit, however, the direct voltage responsible for the shift is only of the order of 5 volts or so, and the measuring function is brought about by the simple expedient of metering this shift voltage. The meter is the centre-reading one that can be seen on the photograph. When the trace is centred vertically, and thus directly under the cursor on the tube, the meter reads zero. But if the vertical shift control is moved, the meter reads in the positive or negative direction, according to whether the movement of the trace is upwards or downwards, respectively. Suppose now that a waveform is displayed on the tube. If the vertical shift control is moved so as to bring the positive peak directly under the cursor, the meter indicates the exact voltage of the peak, and because both the D.C. shift voltage and the alternating signal voltage are subject to exactly the same amplification through the tube circuit, the reading is independent of the gain of the amplifier, and therefore of the setting of the gain control. But if the input attenuator has been switched to the 10 : 1 position, then the voltage reading must be multiplied by 10. The meter has two ranges, 0–5 and 0–50 volts, so that in conjunction with the attenuator, voltages up to 500 may be measured.

This system of measurement is a vast improvement over other similar schemes, in which the shift voltage actually applied to the Y plates is measured, because in that case, the gain of the amplifier must be accurately known, but here, the measurement does not depend on this at all.

To sum up, then, the E.M.I. oscilloscope is a very attractive little instrument, more than capable of earning its keep in any laboratory or service workshop, and which by careful design, has brought into the medium-price range features often to be found only in much more expensive equipment. The approximate price will be £40 plus tax.

BINDERS FOR "R. & E."

These are available to hold 12 issues—price 5s. 6d. Please remit cash with order to Radio and Electronics (N.Z.), Ltd., P.O. Box 8022, Wellington.



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Abstract Service

(Continued from Page 19.)

A compact 10-metre mobile transmitter that can be carried under the dashboard.

—*Radio and Television News* (U.S.A.), July, 1951, p. 46.

Frequency modulation—a simple explanation of the frequency discriminator circuits of the receiver.

—*Wireless World* (Eng.), July 1951, p. 271.

Printed Electronic Circuits

(Continued from Page 21.)

and then dusting on the powder so that it is held in place by the adhesive until fired.

SERVICING PRINTED CIRCUITS

As was mentioned above, the most convenient method of making repairs and replacements in printed circuits is the brush-applied painting technique. Kits of such paints, including both conductor and resistor mixtures, are commercially available. Most of these paints require no heat for drying, so that they may be used for repairing circuits having parts which cannot be subjected to high temperatures. This is an important precaution when working with circuits printed on certain types of plastic.

Although subminiature tube sockets are sometimes used with printed circuits, tubes are frequently connected directly to metal eyelets in the base plate, as in Fig. 1. When replacing tubes connected in this manner, care must be exercised to avoid the use of excessive heat during soldering operations. Soldered connections may also be made directly to printed conductors if the base material will stand the heat involved. A solder containing a small percentage of silver should be used for best results. Where soldering is inadvisable, connections to tube leads and other wires should be made with metallic paint.

Printed resistors which have become defective may be repaired or replaced by the painting technique. Defective resistors are located in the usual manner with an ohmmeter. If it becomes necessary to "disconnect" a printed resistor from the circuit for a resistance check, this may be accomplished by scratching through the printed conductor lead with a sharp instrument. If defective, the resistor may be repaired with resistive paint. It will usually be found to be open or high in value. In such cases, additional resistive paint should be applied over the old resistor to reduce its resistance to the proper value. Some commercial printed circuits have a protective layer of lacquer over the conductors and particularly over resistors to prevent moisture absorption. This coating must be completely removed before repairing resistors. If attempts to repair defective resistors are unsuccessful, the old coating should be removed completely and a new resistor painted in its place. The proper dimensions may be determined by trial and error, keeping in mind that the resistance is directly proportional to the length, and inversely proportional to width and thickness. The resistance material must make good contact with the printed conductors at the ends. Breaks introduced in the conductors to isolate resistors may be repaired with a bridge of conducting paint.

Philips Experimenter

(Continued from Page 25.)

ment on several long radio circuits, such as from Holland to America, and again, from Holland to the East Indies. When A.M. is used for such circuits, the usual practice is to use triple-diversity reception as a means of combating the distortion and loss if intelligibility caused by selective fading. It has been found that when S.S.S.C. transmission was introduced, results equal to those obtained on a triple-diversity A.M. set-up were obtained with only a single receiver when S.S.S.C. was used. This means that for long-distance work, S.S.S.C. users will be at a tremendous advantage compared with those who stick to A.M.

Of course, changing over will not always be easy, particularly for those who are not so technically inclined as others. However, one of the most attractive features of amateur radio has always been that it has never lacked new worlds to conquer—worlds that have been a challenge to the initiative and resource of "hams" the world over. Here is a new one—one that can give added pleasure to everyone in the "ham" game. Ensuing issues of the Experimenter will show how S.S.S.C., can be accomplished, and what the tricks of the new techniques are. The rest is over to you.

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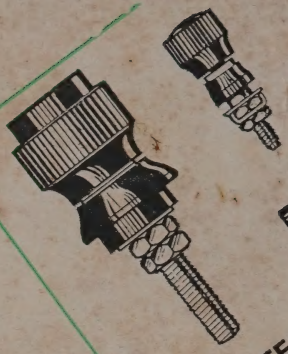
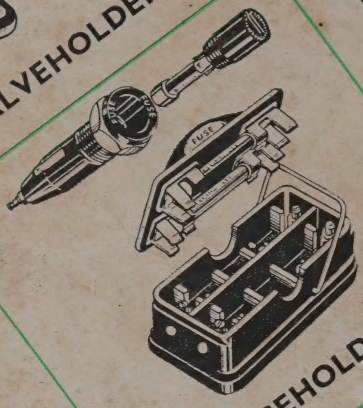


TERMINALS



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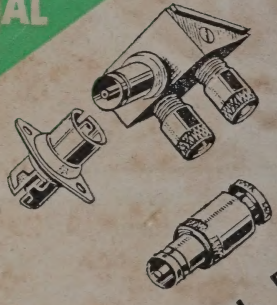

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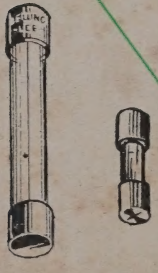

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